STRUCTURAL PRACTICES

Check Dam - CD

DEFINITION

Small temporary barrier, grade control structure, or dam constructed across a swale, drainage ditch, or area of concentrated flow.

PURPOSE

To minimize the erosion rate by reducing the velocity of storm water in areas of concentrated flow, and to capture larger soil particles.

CONDITIONS

This practice is applicable for use in small open channels and **is not to be used in a stream**. Specific applications include:

- Temporary or permanent swales or ditches in need of protection during establishment of grass linings.
- Temporary or permanent swales or ditches that, due to their short length of service or for other reasons, cannot receive a permanent non-erodible lining for an extended period of time.
- Other locations where small localized erosion and sedimentation problems exist.

DESIGN CRITERIA

Formal design is not required. The following standards should be used:

Drainage Area: For stone check dams, the drainage area should not exceed one acre. For rock check dams, the drainage area should not exceed five acres.

Spacing: Two or more check dams in series should be used for drainage areas greater than one acre. Maximum spacing between dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam. (See Figure 1)

Height: The center of the check dam should be at least 9 inches lower than outer edges. Dam height should be 2 feet maximum measured to the center of the check dam. (See Figure 2)

Side Slopes: Side slopes should be 2:l or less.

Geotextiles: A geotextile should be used as a separator between the graded stone and the soil base and abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. Geotextiles should be "set" into the subgrade soils. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend five feet beyond the down stream toe of the dam to prevent scour. Refer to specification **Geotextile – GE**.

CONSTRUCTION SPECIFICATIONS

The following types of check dams are used for this standard:

Stone Check Dams - CD-S: Stone check dams are constructed from large aggregate (clean of fines) such as TDOT #1 or #2 with a minimum stone size of 1.5 inch. These structures are used **for small drainage areas up to 1 acre**.

Rock Check Dam - CD-R: Rock check dams are constructed from small riprap such as TDOT Class A-1 (clean of fines) with stone sizes from 2 to 15 inches. These structures are used **for drainage areas up to 5 acres**. An upstream layer of smaller aggregate may be used for filtering. Rock can be placed by hand or by mechanical methods (no dumping of rock) to achieve complete ditch or swale coverage. Refer to **Riprap - RR** for riprap and aggregate specifications.

Rock check dams should be keyed into the swale or channel bottom at, typically, a depth of 6 inches. Advantages of keying into the swale or channel bottom are that the check dam will be more stable and less likely to wash out. A disadvantage of keying into the swale or channel bottom is that the channel will have to be repaired and reshaped whenever the rock check dam is removed.

Sandbag Check Dam - CD-SB: Sandbags filled with either aggregate or sand may also be used as a check dam. Sandbags should be staked and tied together, after being placed in a staggered fashion. Provide an overflow weir in the center of the channel similar to the check dam in Figure 2.

INSPECTION

Inspections of erosion control measures should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

Sediment should be removed before it reaches a depth of one-half the original dam height. Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

If the area is to be mowed, check dams should be removed once final stabilization has occurred. Otherwise, check dams may remain in place permanently. After removal, the disturbed area should be seeded and mulched immediately.

Spacing Between Check Dams

L = The distance such that points A and B are of equal elevation

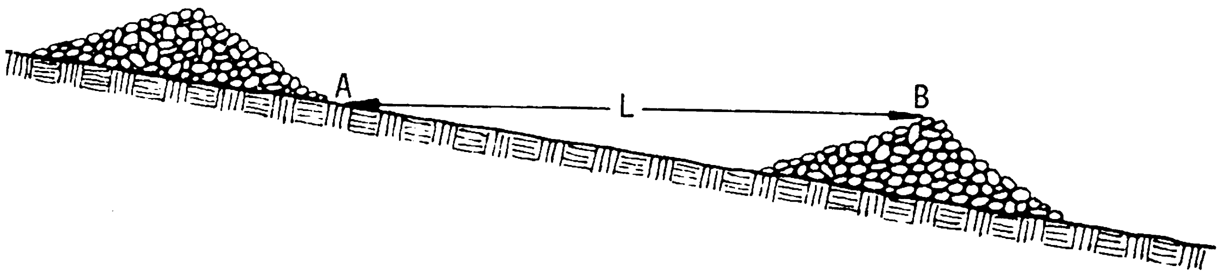
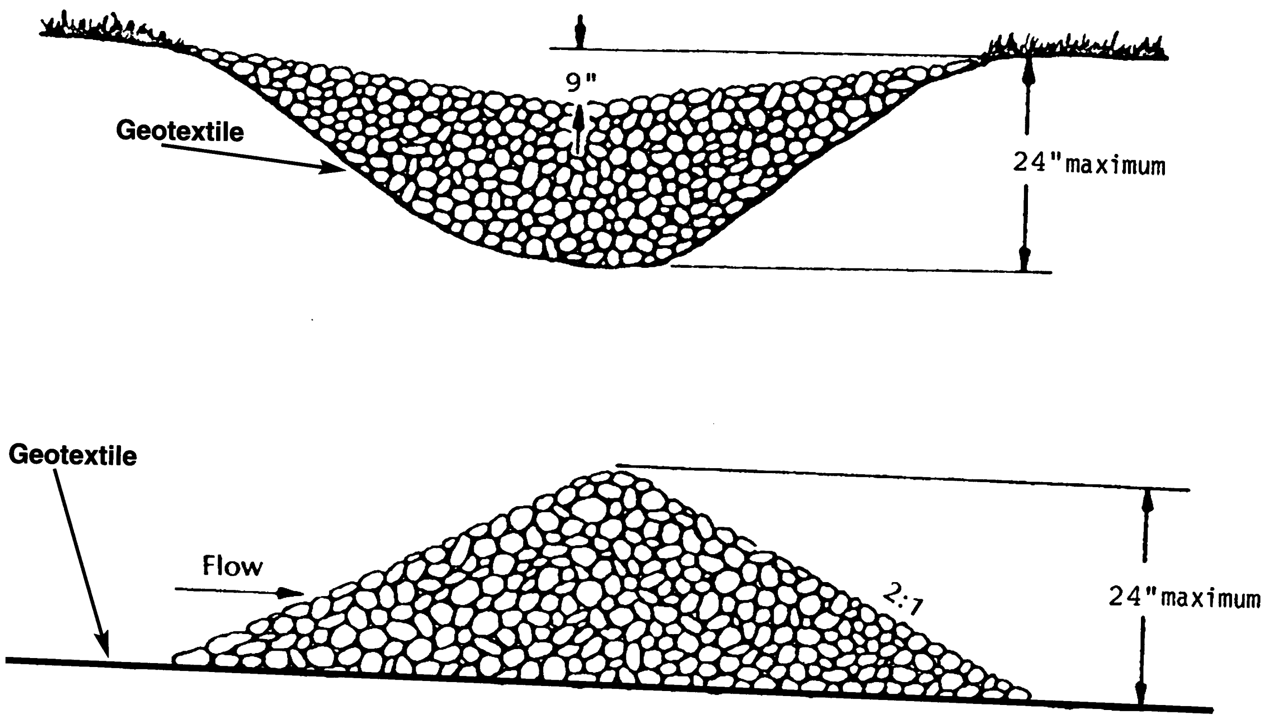


Figure 1

Height Of Check Dams



Source: GA SWCCC

Figure 2

Construction Exit - CE

DEFINITION

A stone-stabilized pad located at any point where traffic will be leaving a construction site to a public roadway.

PURPOSE

To reduce or eliminate the transport of material from the construction area onto a public roadway.

CONDITIONS

This practice is applied at appropriate points of construction egress. Geotextile under-liners are required to stabilize and support the pad aggregates.

DESIGN CRITERIA

Formal design is not required. A typical construction exit is shown in Figure 1. The following standards should be used:

Aggregate Size: Stone should be in accordance with TDOT #1 or #2 stone specifications (1.5 to 3.5 inch stone), washed, and well graded. Refer to specification **Riprap – RR** for aggregate size tables.

Pad Thickness: The gravel pad should have a minimum thickness of 6 inches.

Pad Length and Width: At a minimum, the width should equal full width of all points of vehicular egress, but not less than 20 feet wide. Pad length should be no less than 50 feet.

Washing: If the action of the vehicle traveling over the gravel pad does not sufficiently remove the material, the tires should be washed prior to exit onto public roadways. When washing is required, the wash rack should be designed for the anticipated traffic loads and placed on level ground, on a pad of coarse aggregate (such as TDOT #57). A typical wash rack is shown in Figure 2. The wash rack design may consist of other materials suitable for truck traffic that remove mud and dirt. The wash rack should have provisions that intercept the sediment-laden runoff and direct it into a sediment trap or sediment basin.

Location: The exit should be located wherever traffic will be leaving a construction site directly onto a public roadway.

CONSTRUCTION SPECIFICATIONS

It is recommended that the exit area be excavated to a depth of 3 inches and be cleared of all vegetation and roots.

Waterbar Diversion: On sites where the grade toward the public roadway is greater than 2%, a waterbar diversion 6 to 8 inches high with 3:l side slopes should be constructed across the foundation of the construction exit to prevent storm water runoff from leaving the site. Refer to specification **Diversion – DI.** Diverted runoff should be directed into a sediment trap or sediment basin. Refer to specification **Sediment Trap – ST** or **Sediment Basin – SB.**

Geotextile: The geotextile under-liner must be placed the full length and width of the exit. Refer to specification **Geotextile – GE.**

INSPECTIONS

Inspections of construction exit should be made at the end of each shift or workday.

MAINTENANCE

The exit should be maintained in a condition that will prevent tracking or flow of material onto public rights-of-way. This may require periodic top dressing with fresh stone, as conditions demand, and repair and/or cleanout of any structures to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles or site onto roadways or into storm drains must be removed immediately.

Construction Exit

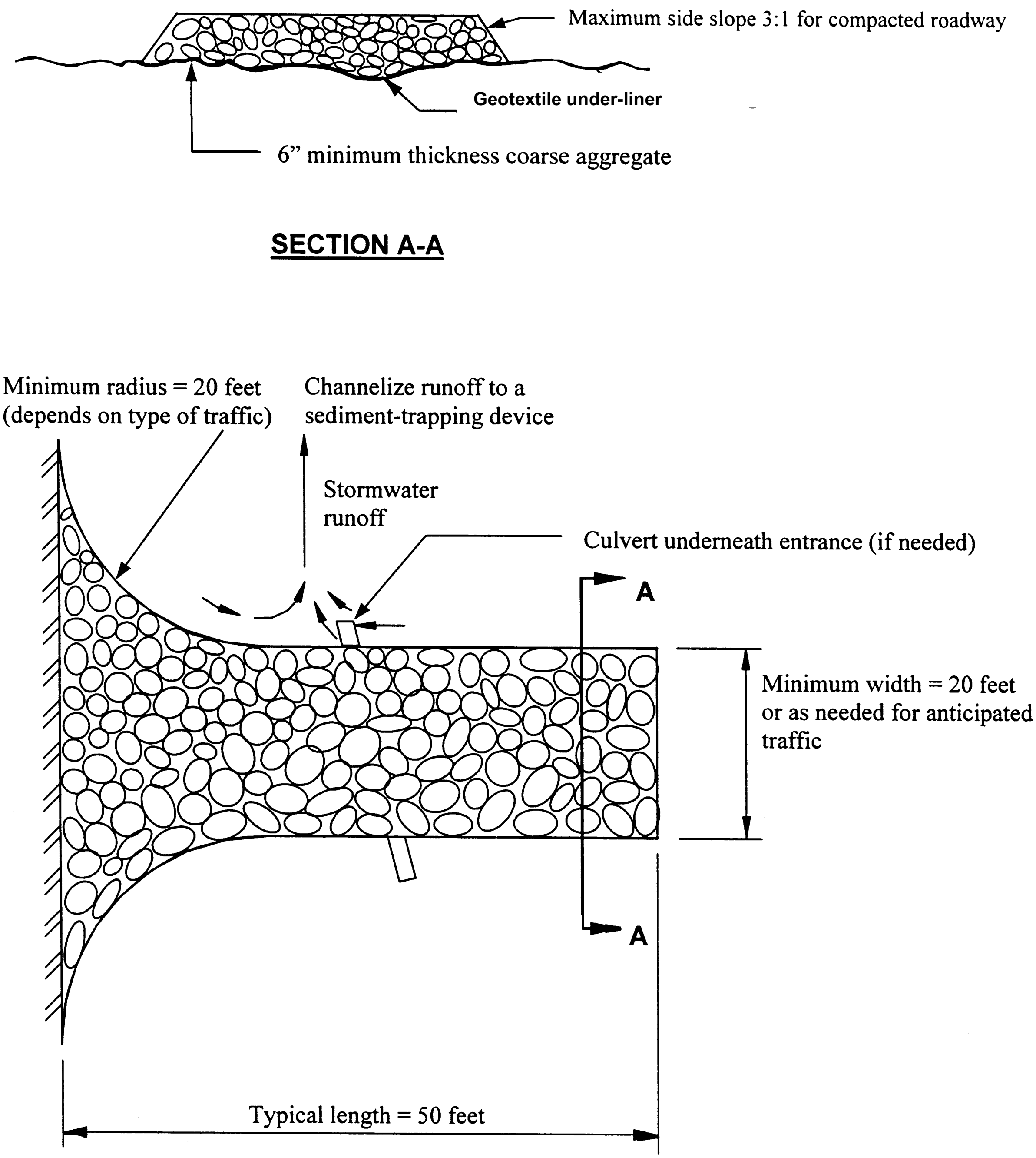
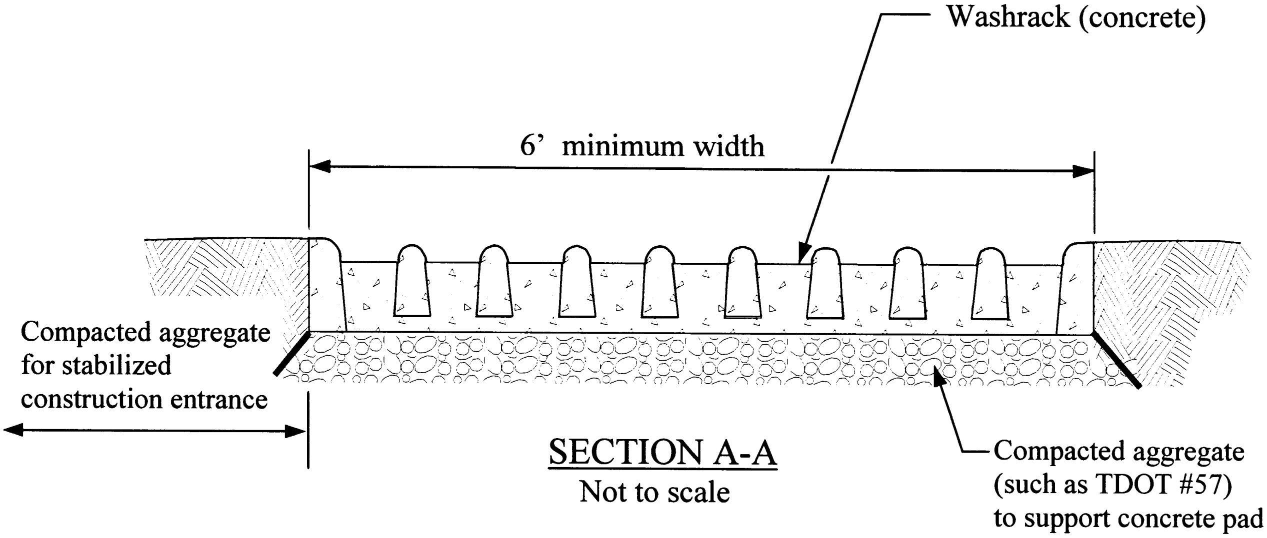
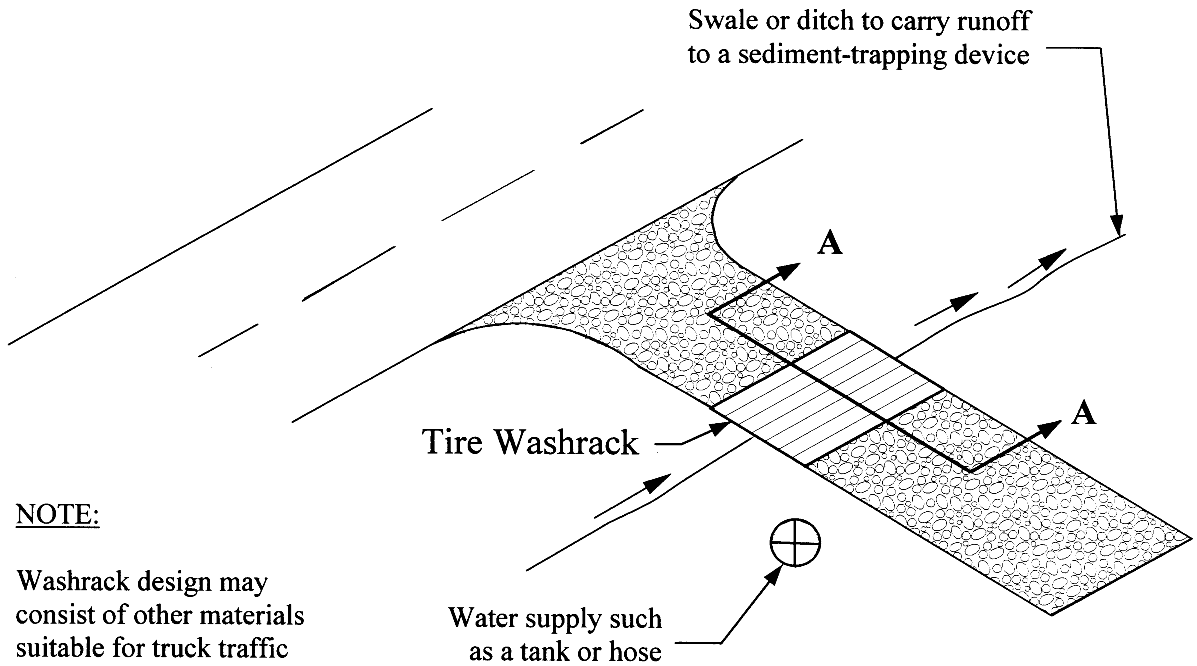


Figure 1

Source: Knoxville Engineering Department

Typical Washrack for Construction Exit





NOTE:

Washrack design may consist of other materials suitable for truck traffic that remove mud and dirt.

Figure 2

Source: Knoxville Engineering Department

Construction Road Stabilization - CRS

DEFINITION

The use of construction specifications, techniques, and materials to stabilize soils on which a travel way is constructed as part of a construction plan. A travel way may include access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes not accessible to public traffic.

PURPOSE

To provide a fixed route for construction traffic, and to reduce erosion and subsequent re-grading of permanent roadbeds between the time of initial grading and final stabilization.

CONDITIONS

This practice is applicable where travel ways are needed in a planned land use area or wherever stone-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

PLANNING CONSIDERATIONS

Areas graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil is continually disturbed, eliminating the possibility of stabilization with vegetation. The prolonged exposure of the roads and parking areas to surface runoff can create severe rill erosion and/or sedimentation, requiring regrading before paving. The soil removed during this process may enter streams and other waters of the state, compromising water quality. Additionally, because unfinished roads become so unstable during wet weather, they are virtually unusable, limiting access, and causing delays in construction

DESIGN CRITERIA

The application of this practice does not require formal design. The following standards should be used:

Temporary Roads and Parking Areas

Location: Temporary roads should be located to serve the purpose intended; facilitate the control and disposal of water; control or reduce erosion; and make the best use of topographic features. Temporary parking areas should be located on naturally flat areas to minimize grading.

Temporary roads should follow the contour of the natural terrain to minimize disturbance of drainage patterns. If a temporary road must cross a stream, the crossing must be designed, installed, and maintained according to specification **Temporary Stream Crossing - TSC.**

<u>All stream crossings require authorization from the Tennessee Division of Water Pollution Control and United States Army Corps of Engineers prior to construction.</u> For more information, see Appendix C and: http://www.state.tn.us/environment/permits/arap.htm

Grade and Alignment: The gradient and vertical and horizontal alignment should be adapted to the intensity of use, mode of travel, and level of development. Grades for temporary roads should not exceed ten percent except for very short lengths (200 feet or less), but maximum grades of 20 percent or more may be used if necessary for special uses. Frequent grade changes generally cause fewer erosion problems than long continuous gradients. Grades for temporary parking areas should be sufficient to provide drainage but should not exceed four percent.

Curves and switchbacks must be of sufficient radius for trucks and other large vehicles to negotiate easily. On temporary roads, the radius should be no less than 35 feet for standard vehicles and 50 feet for tractor-trailers.

Width: Temporary roadbeds should be at least 14 feet wide for one-way traffic and 20 feet wide for two-way traffic. The width for two-way traffic should be increased approximately four feet for trailer traffic. A minimum shoulder width should be two feet on each side. Where turnouts are used, road width should be increased to a minimum of 20 feet for a distance of 30 feet.

Side Slopes: All cuts and/or fills should have side slopes designed to be stable for the particular site conditions and soil materials involved. All cuts and/or fills should be 2:l or less, to the extent possible. When maintenance by machine mowing is planned, side slopes should be no steeper than 3:l.

Drainage: The type of drainage structure used will depend on the type of activity and runoff conditions. The capacity and design should be consistent with sound engineering principles and should be adequate for the class of vehicle, type of road, development, or use. Structures should be designed to withstand flows from a 25-year, 24-hour frequency storm. Ditches should be designed to be on stable grades and/or protected with structures or linings for stability.

Water breaks or bars may be used to control surface runoff on low-intensity use roads. Refer to specification **Diversion – DI.**

Stabilization: A 6-inch layer of coarse aggregate, such as TDOT #57, should be applied immediately after grading or the completion of utility installation within the right-of-way. In areas experiencing heavy traffic, stone should be placed at an 8 to l0 inch depth to avoid excessive dissipation or maintenance needs.

Geotextile should be applied beneath the stone for additional stability. Refer to specification **Geotextile – GE**.

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads should be stabilized with appropriate temporary or permanent seeding according to specification in **Disturbed Area Stabilization (With Temporary Vegetation) - TS** and **Disturbed Area Stabilization (With Permanent Vegetation) – PS,** or with rock armoring according to specification in **Riprap – RR.**

Permanent Roads and Parking Areas

Permanent roads and parking areas should be designed and constructed according to criteria established by the local authority and TDOT. Permanent roads and parking areas should be stabilized in accordance with this specification, applying an initial base course of gravel immediately following grading.

CONSTRUCTION SPECIFICATIONS

1. Trees, stumps, brush, roots, weeds, and other objectionable materials should be removed from the work area.

2. Unsuitable material should be removed from the roadbed and parking areas.

3. Grading, subgrade preparation, and compaction should be done as needed. Fill material should be deposited in layers not to exceed 9 inches and compacted with the controlled movement of compacting and earth moving equipment.

4. The roadbed and parking area should be graded to the required elevation. Subgrade preparation and placement of the surface layer should be in accordance with sound highway construction practice.

5. Structures such as culverts, pipe drops, or bridges should be installed to the lines and grades shown on the plans or as staked in the field. Culverts should be placed on a firm foundation. Selected backfill material should be placed around the culvert in layers not to exceed 6 inches. Each layer should be properly compacted.

6. Roads should be planned and laid out with storm water flow paths in mind.

INSPECTIONS

Inspections of erosion control measures should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

Add top dressing of stone to roads and parking areas to maintain a gravel depth of 6 inches.

Remove any silt or other debris causing clogging of roadside ditches or other drainage structure.

Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Dewatering Structure - DW

DEFINITION

A temporary structure for settling and/or filtering sediment-laden water that is discharged from dewatering activities.

PURPOSE

To settle and filter sediment-laden water prior to the water being discharged off-site.

CONDITIONS

Wherever sediment-laden water must be removed from a construction activity by means of pumping.

PLANNING CONSIDERATIONS

Water that is pumped from a construction site usually contains a large amount of sediment. A dewatering structure is typically needed to remove the sediment before water is released off-site.

One of several types of dewatering structures may be constructed depending upon site conditions and type of operation. A well stabilized, onsite, vegetated area may serve as a dewatering device if the area is stabilized so that it can filter sediment and at the same time withstand the velocity of the discharged water without eroding. The discharge of sediment-laden water onto a vegetated area should not pose a threat to the survival of the existing vegetative stand through smothering by sedimentation. A minimum filtering length of **75 feet** must be available in order for such a method to be feasible.

DESIGN CRITERIA

Formal design is not required. The following information should be considered:

A dewatering structure must be sized (and operated) to allow pumped water to flow through the filtering device **without overtopping** the structure. An excavated basin may be lined with geotextile to help reduce scour and to prevent the inclusion of soil from within the structure. Types of dewatering devices are shown in Figures 1 and 2.

CONSTRUCTION SPECIFICATIONS

Portable Sediment Tank (see Figure 1)

Materials: The sediment tank may be constructed with steel drums, sturdy wood or other material suitable for handling the pressure exerted by the volume of water. The structure should have a minimum depth of two feet.

Location: The location for the sediment tank should be chosen for easy clean-out and disposal of the trapped sediment, and to minimize the interference with construction activities.

Storage Volume: The following formula should be used to determine the storage volume of the sediment tank:

Pump discharge (gpm) x 16 = cubic feet of storage required

Operation: Once the water level nears the top of the tank, **the pump must be shut off** while the tank drains and additional capacity is made available. The tank should be designed to allow for emergency flow over the top of the tank. Clean-out of the tank is required once one-third of the original capacity is depleted due to sediment accumulation. The tank should be clearly marked showing the clean-out point.

Straw Bale /Silt Fence Pit (see Figure 2)

Materials: The straw bale/silt fence pit should consist of straw bales, silt fence, a stone outlet (a combination of TDOT Class A-1 Riprap and TDOT #1 Aggregate) and an excavated wet storage pit.

Storage Volume: The following formula should be used to determine the storage volume of the straw bale/silt fence pit:

Pump discharge (gpm) x 16 = cubic feet of storage required

In calculating the capacity, one should include the volume available from the floor of the excavation to the crest of the stone weir. In any case, the excavated area should be a minimum of 3 feet below the base of the perimeter measures (straw bales or silt fence). The perimeter measures must be installed according to the specification **Silt Fence- SF**.

Operation: Once the water level nears the crest of the stone weir (emergency overflow), **the pump must be shut off** while the structure drains down to the elevation of the excavated area. The remaining water may be removed only after a minimum of 6 hours of sediment settling time. This effluent should be pumped across an area with established vegetation or through a silt fence prior to entering a watercourse. When the excavated area becomes filled to one-half of the excavated depth, accumulated sediment should be removed and properly disposed of.

Sediment Filter Bag (see Photograph)

Materials: The filter bag should be constructed of non-woven geotextile material that will provide adequate filtering ability to capture the larger soil particles from the pumped water. The bag should be constructed so that there is an inlet neck that may be clamped around the dewatering pump discharge hose so that all of the pumped water passes through the bag.

Location: The filter bag should be used in combination with a straw bale/silt fence pit when located within 50 feet of a stream. When the distance to a stream is greater than 50 feet, the bag may be placed on well-established grass, or on an aggregate pad constructed of TDOT # 57 stone at a minimum depth of 6 inches. The bag should never be placed on bare soil.

Storage Volume: The capacity of the sediment filter bag should be adequate to handle the dewatering pump discharge, and should be based on the bag manufacturer's recommendation.

Operation: When used in conjunction with a straw bale/silt fence pit, a filter bag may be operated until the water in the pit reaches the crest of the emergency overflow. **The pump must be shut off** at this point.

When placed on either a stone pad or well-established grass, the pad may be operated until such time the discharge from the bag reaches a stream. Unless the discharge is at least as clear as the receiving water, **the pump must be shut off** at this point.

Disposal: When the bag has been completely filled with sediment it should be cut open, regraded in place, and immediately stabilized with either sod or erosion control blanket. Refer to specifications **Disturbed Area Stabilization (with Sod) – SO**, or **Erosion Control Blanket/Matting – MA**, respectively.

MAINTENANCE

The filtering devices must be inspected frequently and repaired or replaced once the sediment build-up prevents the structure from functioning as designed.

The accumulated sediment which is removed from a dewatering device must be spread on-site and stabilized or disposed of at an approved disposal site as per the SWPPP.

Portable Sediment Tank

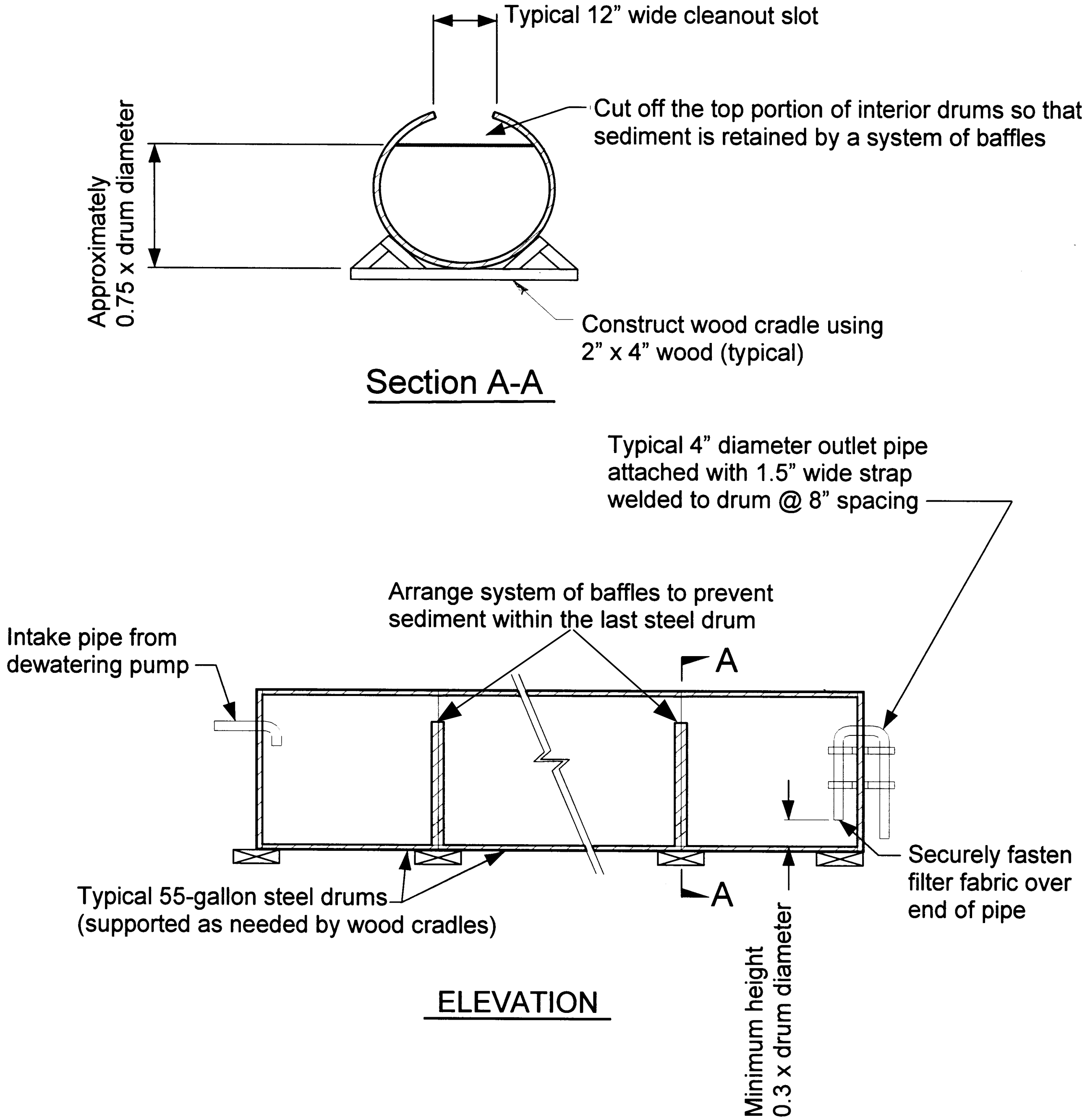


Figure 1

Source: Knoxville Engineering Department

Straw Bale/Silt Fence Pit

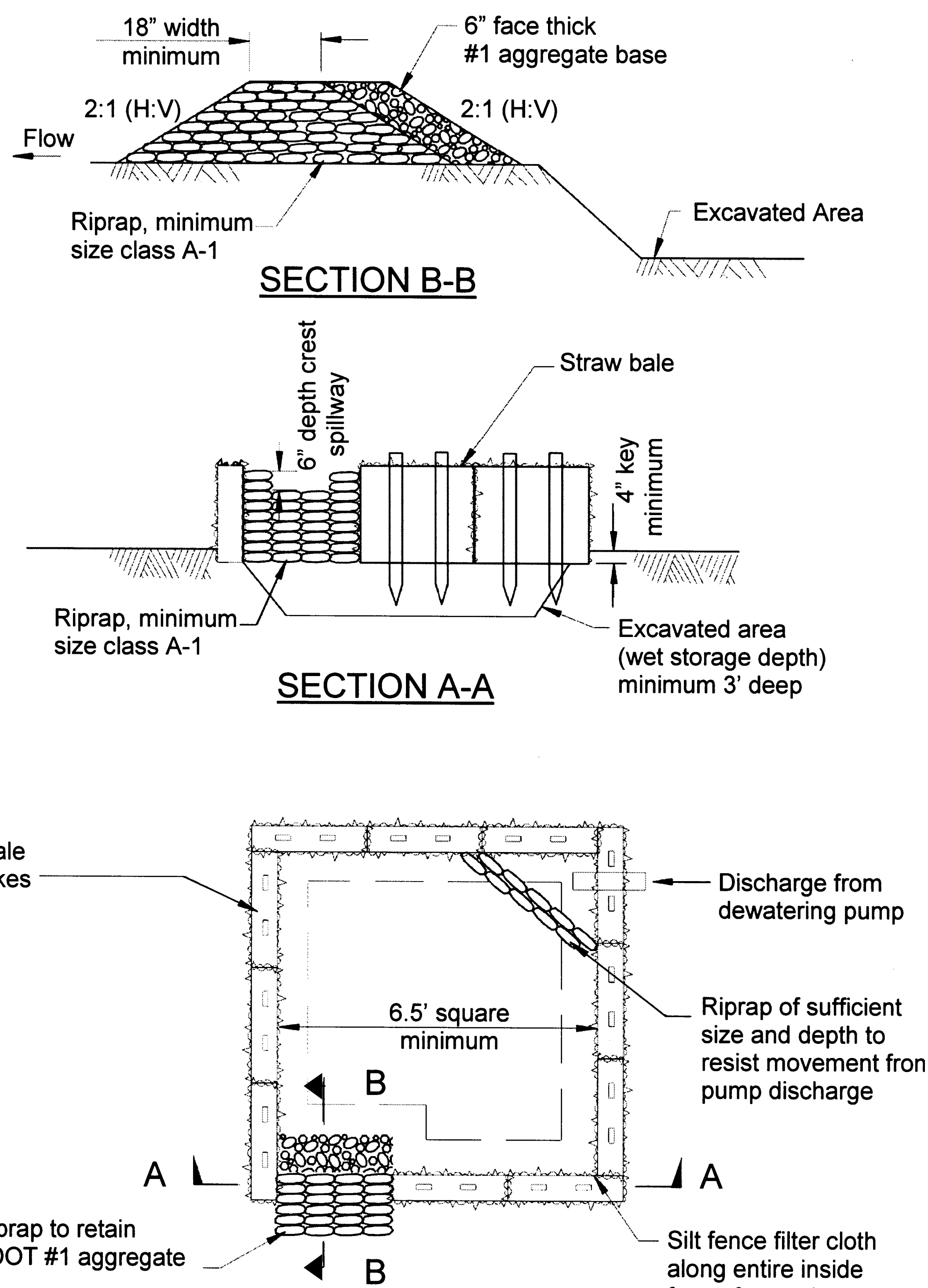


Figure 2

Source: Knoxville Engineering Department

Diversion - DI

DEFINITION

A channel of compacted soil constructed above, across, or below a slope, with a supporting earthen ridge on the lower side.

PURPOSE

To reduce the erosion of steep, or otherwise highly erodible areas by reducing slope lengths, intercepting storm runoff and diverting it to a stable outlet at a non-erosive velocity, or to convey storm water through a construction site.

CONDITIONS

This standard applies to temporary and permanent diversions in land-disturbing activities. Diversions are applicable where:

- The slope length needs to be reduced to minimize erosion.
- Runoff from upslope areas is, or has the potential for, damaging property, flooding, or preventing the establishment of vegetation on lower areas.
- Clean storm water is coming onto the site and needs to be conveyed across or around the disturbed area to prevent contamination.

DESIGN CRITERIA

Professionals familiar with the design of storm water conveyance systems should prepare construction plans and drawings for diversion designs. A diversion consists of two components: the ridge and the channel.

Ridge Design: The ridge should be compacted and designed to have stable side slopes, which should not be steeper than 2:l. When maintenance by machine mowing is planned, side slopes should be no steeper than 3:1. The ridge should be a minimum width of four feet at the design water elevation after settlement. Its design should allow for ten percent settlement.

Channel Design: Land slope must be taken into consideration when choosing channel dimensions. On the steeper slopes, narrow and deep channels may be required. On the more gentle slopes, broad, shallow channels usually are applicable. The wide, shallow section will be easier to maintain. Since sediment deposition is often a problem in diversions, the designed flow velocity should be kept as high as the channel lining will permit. Unless the purpose of the diversion is to convey clean water around the disturbed area, a diversion should lead to a sediment-trapping device.

Table 1 lists minimum design criteria for diversions. The storm frequency is used to determine the required channel capacity (peak rate of runoff).

The channel portion of the diversion may have a parabolic, trapezoidal, or vee-shaped cross-section, as shown in Figure 1. Professional design following sound engineering practice must be used to compute the capacity and dimension of the channel.

Location: Diversion location should be determined by considering outlet conditions, topography, land use, soil type, length of slope, seep planes (when seepage is a problem), and the development layout. Diversions should be tailored to fit the conditions for particular location and soil type(s).

Outlets: Each diversion must have an adequate outlet. The outlet may be a constructed or natural waterway, a stabilized vegetated area or another energy dissipation device. Refer to specification **Storm Drain Outlet Protection – OP**. In all cases, the outlet must discharge in such a manner as to not cause erosion or sedimentation problems. Protected outlets should be constructed and stabilized prior to construction of the diversion.

Stabilization: Channels should be stabilized in accordance with sound engineering practice to provide adequate stability for expected water velocities.

WATERBAR DIVERSIONS FOR ROADS

A detailed design is not required for this type of diversion. Diversions installed to divert water off a road or right-of-way should consist of a series of compacted ridges of soil running diagonally across the road at a 30º angle. Ridges are constructed by excavating a channel up-slope, and using the excavated material for the compacted ridge.

The compacted ridge height should be 8-12" above the original road surface; the channel depth should be 8- 12" below the original road surface. Channel bottoms and ridge tops should be smooth enough to be crossed by vehicular traffic. The maximum spacing between diversions is shown in Table 2. Waterbars should discharge to a stabilized conveyance that carries the storm water to an approved outlet or treatment structure.

CONSTRUCTION SPECIFICATIONS

1. All trees, brush, stumps, obstructions, and other objectionable material should be removed and disposed of so as not to interfere with the proper functioning of the diversion.

2. The diversion should be excavated or shaped to line, grade, and cross section as designed to meet the criteria specified herein and be free of irregularities that will impede normal flow.

3. All fills should be machine compacted as needed to prevent unequal settlement that would cause damage in the completed diversion.

4. All earth removed and not needed in construction should be spread or disposed of so that it will not interfere with the functioning of the diversion.

5. Diversion channels should be stabilized in accordance with designed plans and specifications.

INSPECTION

Inspections of erosion control measures should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Diversion Design Criteria

Diversion Type	Land or Improvement Protected	Storm Frequency	Freeboard	Minimum Ridge Width
Temporary	Construction Areas	2yr / 24 hr	0.3	4 feet
Permanent	Landscaped, recreation and similar areas	25yr / 24hr	0.3	4 feet
Permanent	Dwellings, schools, commercial bldgs., and similar installations	50yr / 24hr	0.5	4 feet

Table 1

Source: GA SWCC

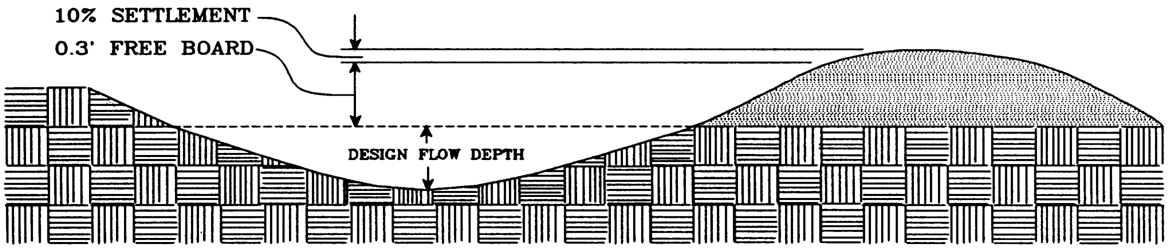
Maximum Spacing Between Waterbar Diversions

Road Grade (Percent)	Distance Between Diversions (Feet)
1	400
2	250
5	125
10	80
15	60
20	50

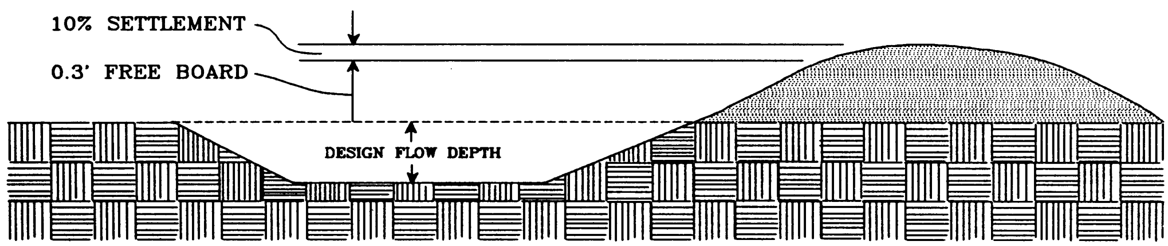
Table 2

Source: GA SWCC

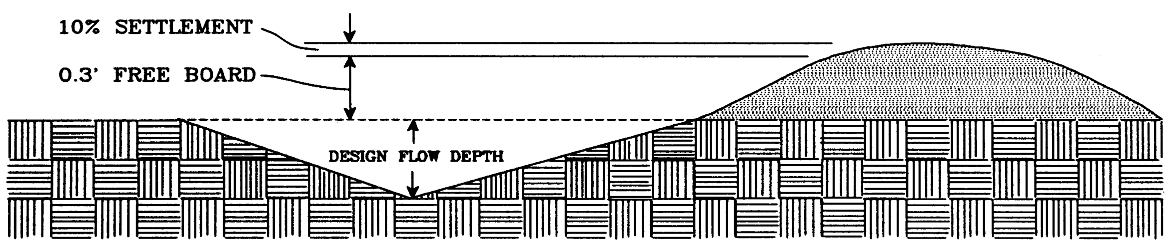
Typical Diversion Cross-Sections



Typical Parabolic Diversion



Typical Trapezoidal Diversion



Typical Vee-Shaped Diversion

Figure 1

Source: VA DSWC

Filter Ring - FR

DEFINITION

A temporary stone barrier constructed at storm drain inlets.

PURPOSE

This structure is used to reduce flow velocities and prevent the failure of other sediment control devices. It also prevents sediment from leaving the site or entering drainage systems, prior to permanent stabilization of the disturbed area.

CONDITIONS

Filter rings should be used in combination with other sediment control measures. They can be installed at or around devices such as storm drain inlets or slope drain inlets.

DESIGN CRITERIA

Formal design is not required. The following standards should be used:

Location: The filter ring should surround all sides of the structure receiving runoff from disturbed areas. See Figure 1 for a typical stone filter ring. It should be placed a minimum of four feet from the structure. The ring should be constructed so that it does not substantially impound water, causing flooding or damage to adjacent areas.

Stone Size: When utilized at inlets/outlets with diameters less than 12 inches, the filter ring should be constructed of small riprap such as TDOT Class A-3 (clean from fines) with stone sizes from 2 to 6 inches. Refer to **Riprap** - **RR** for riprap and aggregate specifications.

When utilized at inlets with diameters greater than 12 inches, the filter ring should be constructed of small riprap such as TDOT Class A-1 (clean from fines) with stone sizes from 2 to 15 inches.

For added sediment filtering capabilities, the upstream side of the riprap can be faced with smaller coarse aggregate, such as TDOT #57 (clean of fines) with a minimum stone size of ¾ inch.

Geotextiles: A geotextile should be used as a separator between the graded stone and the soil base and abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. Geotextiles should be "set" into the subgrade soils. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend to beneath the inlet to prevent scour within the filter ring. Refer to specification **Geotextile** – **GE.**

Height: The filter ring should be constructed at a height no less than two feet from grade.

CONSTRUCTION SPECIFICATIONS

Mechanical or hand placement of stone should be utilized to uniformly surround the structure to be supplemented. The filter ring may be constructed on natural ground surface, on an excavated surface, or on machine compacted fill. A common failure of filter rings is caused by their placement too close or too high above the structure to be enhanced.

INSPECTION

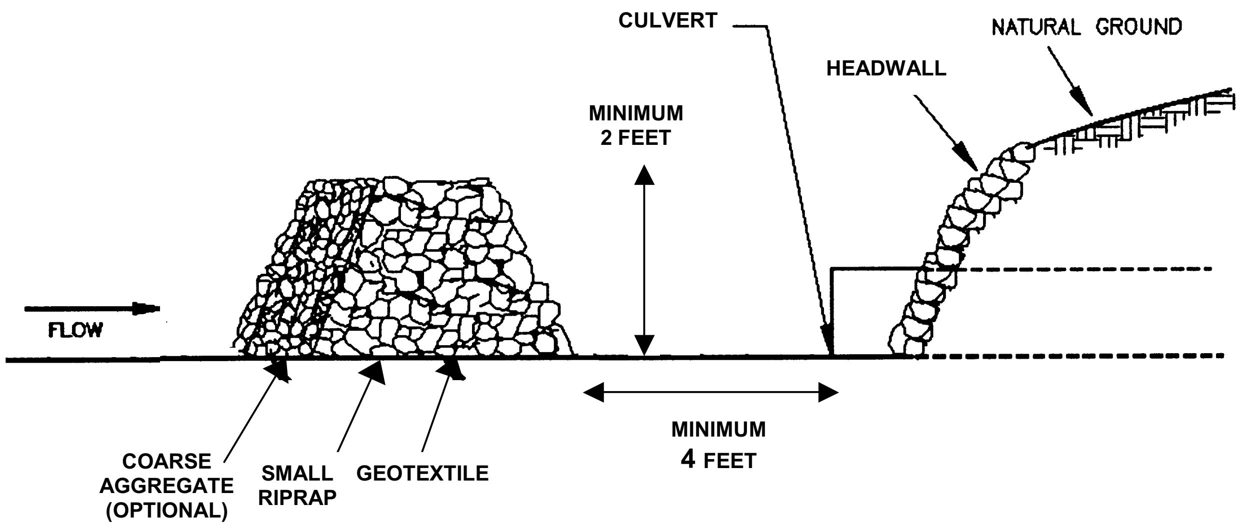
Inspections of the filter ring should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

The filter ring must be kept clear of trash and debris. Sediment should be removed when the level reaches one-half the height of the filter ring. These structures are temporary and should be removed when the land-disturbing project has been stabilized.

Stone Filter Ring

Cross-Section



Perspective View

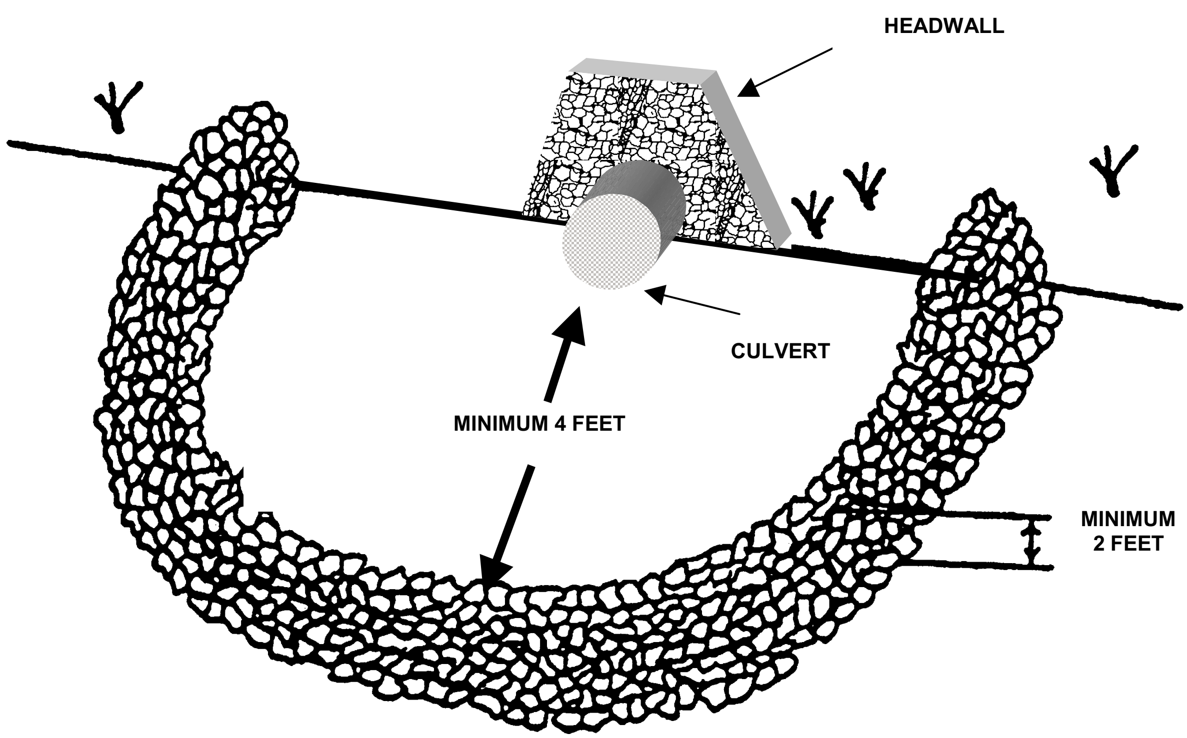


Figure 1

Source: GA SWCC

Gabion - GA

DEFINITION

Large, multi-celled, welded wire or rectangular wire mesh boxes, used as channel revetments, retaining walls, abutments, check dams, etc.

PURPOSE

Rock-filled baskets, properly wired together, to form flexible monolithic building blocks used for construction of erosion control structures and to stabilize steep slopes or highly erosive materials.

CONDITIONS

The practice is applicable wherever slope steepness or erosion potential exceeds the management capacity of less complicated applications. Gabions are typically a permanent or semi-permanent slope and/or soil stabilization application. Typical installations include:

- Retaining walls
- Bridge abutments and wing walls
- Culvert headwalls and outlet aprons
- Shore and beach protection
- Check dams

DESIGN CRITERIA

Professionals familiar with the use of gabions should prepare construction plans and drawings. Erosion and sediment control construction plans should ensure that foundations are properly prepared to receive gabions; that the gabion structure is securely "keyed" into the foundations and abutment surfaces; and that the rock used is durable and adequately sized to be retained in the baskets. See Figure 1 for a typical gabion installation.

CONSTRUCTION SPECIFICATIONS

Filling: The gabion is usually filled with 4 - 8 inch pieces of stone (clean; without fines), preferably placed by hand, but sometimes dumped mechanically, into the basket. Hand packing allows the complete filling of the basket; allowing the basket to gain strength and maintain its integrity. The filled gabion then becomes a large, flexible, and permeable building block from which a broad range of structures may be built. This is done by setting and wiring individual, empty baskets together in courses and filling them in place. The manufacturer should provide installation details.

Geotextiles: It is recommended that geotextiles be used behind all gabion structures. If there is seepage from the excavated soil face, the appropriate geotextile should be selected to prevent the build-up of hydrostatic pressure behind the geotextile. Improper geotextile selection may result in failure of the structure or piping and erosion around the structure. Refer to specification **Geotextile** – **GE.**

Corrosion Resistance of Gabions: The wire mesh or welded wire used in gabions is heavily galvanized. For highly corrosive conditions, a PVC (polyvinyl chloride) coating must be used over the galvanizing. Such treatment is an economical solution to deterioration of the wire near the ocean; in some industrial areas; and/or in polluted streams. However, extra care should be taken during construction and installation because the corrosion resistance of the baskets is compromised if the PVC coating is chipped off. Baskets manufactured completely of plastic are also available. However, estimated required wire strength should be considered in the selection of wire versus plastic.

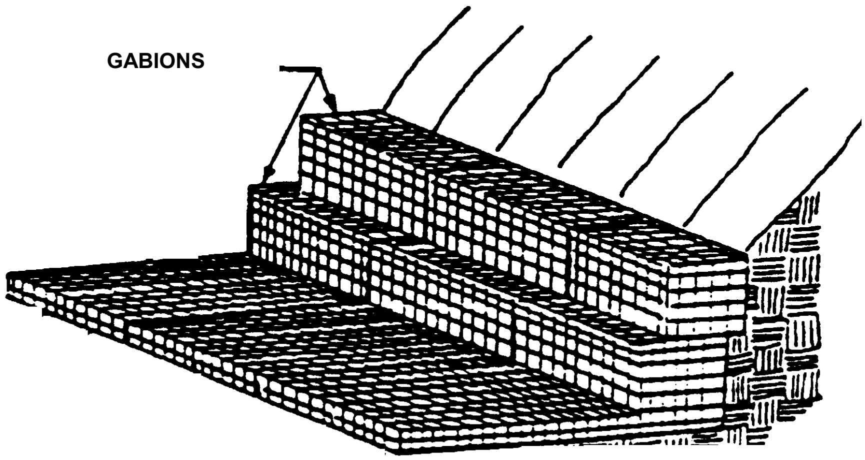
Permeability: If properly designed and constructed, hydrostatic pressure does not develop behind a gabion wall. The wall is pervious to water and stabilizes a slope by the combined action of draining and retaining. Drainage is accomplished by gravity and by evaporation as the porous structure permits active air circulation through it. Moreover, as plant growth invades the structure, transpiration further assists in removing moisture from the backfill.

INSPECTION

Inspect for signs of undercutting or excessive erosion at transition areas, and around or under the structure. Inspections should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

Gabion Installation

Gabion Toe Wall



Gabion Revetment

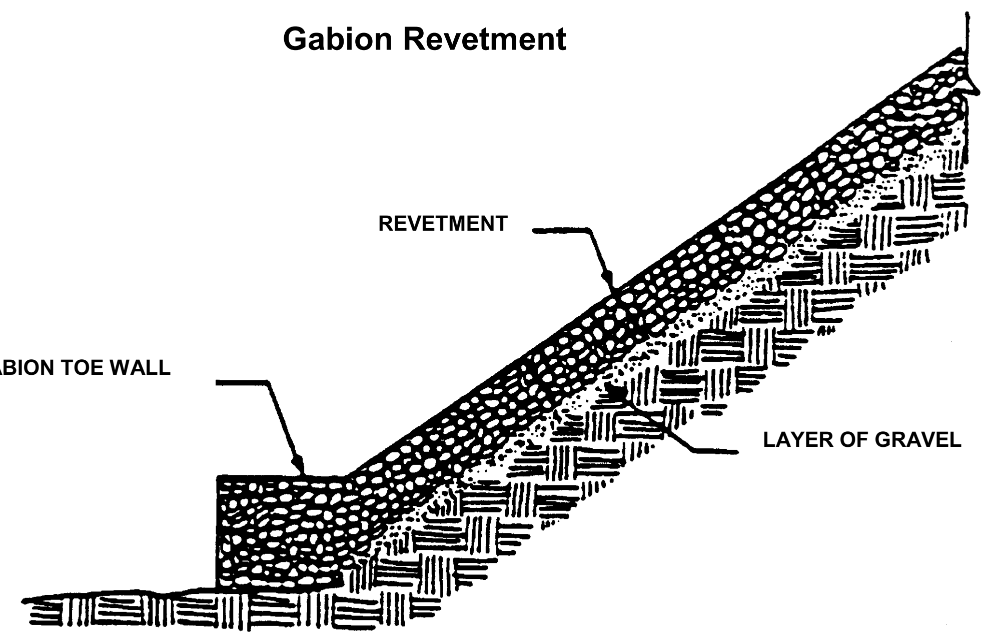


Figure 1

Source: Chattanooga Public Works Department

Geotextile – GE

DEFINITION

A geosynthetic fabric, either woven or non-woven, applied to either the soil surface or between materials.

PURPOSE

To reduce erosion by, and sediment found in, storm generated water by providing filtration, separation, or stabilization properties.

CONDITIONS

Geotextiles provide stabilization, filtration, and separation properties. This standard may be used when there is a need for separation between two materials that are likely to otherwise interfere with one another. Examples of this situation include:

- Separating subsoil from aggregate within a subsurface drain
- Separating subsoil from aggregate placed at the soil surface
- Stabilization of soil surface during temporary stream diversion
- To prevent the buildup of hydrostatic pressure behind gabion, decorative, or retaining walls

DESIGN CRITERIA

The application of geotextile does not require professional design for most uses. If hydrostatic pressure is a concern for stability of a retaining wall, consult a professional experienced in the selection of geotextile fabric.

Geotextile selection should be based on guidelines within AASHTO M288 Standard Specification.

CONSTRUCTION SPECIFICATIONS

Geotextiles should be non-toxic to vegetation, be inert to common chemicals, and be mildew and rot resistant. Materials should meet or exceed the strength, elongation, permittivity, apparent opening size, and ultraviolet stability properties of the requirements outlined in AASHTO M288 for the respective use.

INSTALLATION

Geotextiles should be installed according to manufacturer's specifications. The installation site should be prepared without voids, and without rocks, clods, or debris greater than 1 inch in size. The geotextile should be placed loosely, with no wrinkles or folds, in direct contact with the soil surface.

Overlap of successive sheets should place the upstream or upslope sheet on top of the downslope sheet. Field joining of sheets should be accomplished by sewing or thermal welding for critical applications such as stream diversions or steep slopes. Field joining for regular applications may also be accomplished by overlapping and then using stakes or staples in the overlapped portion. The amount of overlap depends on the size and positioning of the stakes or staples.

Aggregate should be placed carefully onto geotextile to prevent damage. It should never be dumped from a height greater than five feet. Damaged portions may be patched with fabric overlapping on all sides a minimum of one foot, or the specified seam overlap, whichever is greater. Construction vehicles should not be driven directly onto the geotextile.

MAINTENANCE

Geotextiles are generally installed in conjunction with some other practice. Inspections should be conducted simultaneously, and should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Maintenance needs identified in inspections or by other means shall be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Gradient Treatment - GT

DEFINITION

Step or terrace features created along the contour of steep or long slopes.

PURPOSE

Stepped slopes prevent slope erosion and the formation of rills or washes by:

- Decreasing runoff velocities.
- Trapping sediment.
- Increasing infiltration of water into the soil.
- Supporting the establishment of vegetative cover.

CONDITIONS

Stepped or terraced slopes, as well as any permanent slopes which are steeper than 3:1 (H:V), should be designed by a professional based upon actual site conditions. A stepped slope is not practical for sandy soils or other soils with low cohesiveness.

There are several ways to create a gradient terrace that will meet slope stability requirements. Factors to be considered are the steepness of slope, mowing requirements, and whether the slope is formed by fill or by excavation. If terraced slopes become unstable due to diverted flow, alternative measures should be considered. Alternative measures can include flow diversion, drains, and slope stabilization practices.

DESIGN CRITERIA

Contour Furrow – GT-CO: Contour furrows (Figure 1) may be used for slopes which are 3:1 (H:V) or less. Diversion berms or channels may be necessary at the top of slope and along the edges of the slope in order to prevent concentrated storm water runoff from eroding the slope. The maximum distance between furrows should be 40 feet, and the maximum slope length should be 200 feet.

Serrated Slope – GT-SE: A serrated slope (Figure 2) may be used for slopes which are

2:1 (H:V) or less. This type of gradient terrace is labor-intensive in that bladed equipment will be needed to make numerous passes along a slope, beginning at the top and working downward. The maximum slope length should be 100 feet.

Stepped Slope – GT-ST: Graded areas steeper than 3:1 (H:V), which will not be mowed, should preferably have a stepped slope as in Figure 3. The stair-stepping effect will help vegetation become attached and also trap soil eroded from the slopes above. Stepped slopes are particularly appropriate in soils containing rock. Each step catches rocky material, which sloughs from above, and provides a level site where vegetation can become established.

Steps should be wide enough to work with standard earth moving equipment. Preferably the horizontal distance should be at least 1.5 times the vertical cut distance. Slightly grade the horizontal bench inwards (e.g. back towards the top of slope). Do not make individual vertical cuts more than 24 inches high in soft materials or more than 36 inches high in rocky materials.

Terraced Slope – GT-TE: Terraced slopes (Figure 3) should be used on most slopes which are longer than those allowed for other methods. Designed drainage channels are located in the slope at regular intervals. The designed drainage channel has a regular cross-section including slope and depth requirements. It may be necessary to locate intersecting channels to convey storm water to the bottom of the slope. The maximum slope height between terraces shall be 30 feet for cut slopes and 25 feet for fill slopes. Terrace widths should be at least 6 feet wide.

INSPECTION

Inspections of the stepped slope treatment should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

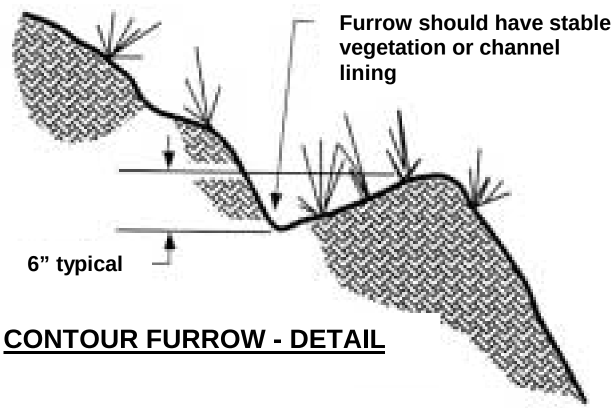
Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Contour Furrow – GT-CO

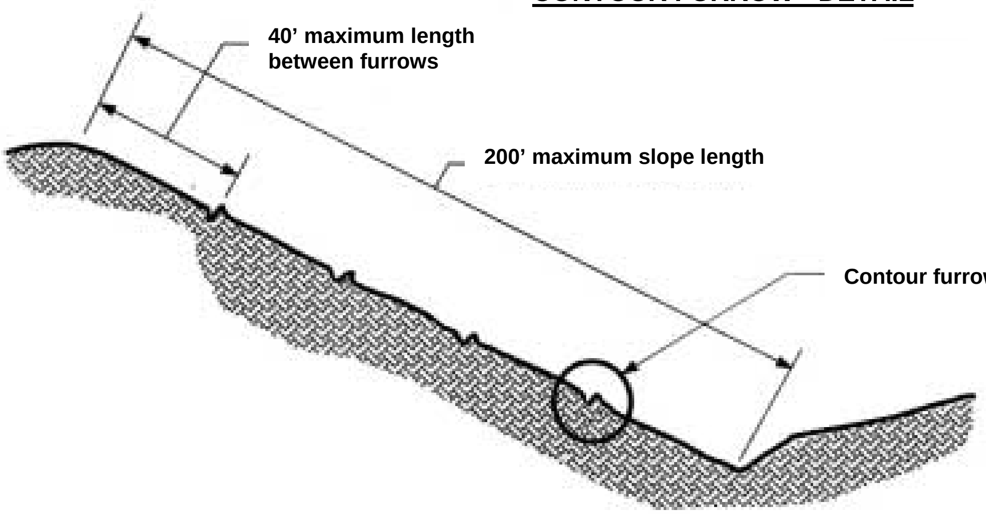
Notes:

1. **Contour furrows will catch fertilizer, seed, mulch, and rainfall to reduce storm water runoff.**

2. **Contour furrows should be designed with appropriate channel slope to safely convey storm water without excessive velocity.**



CONTOUR FURROW - DETAIL



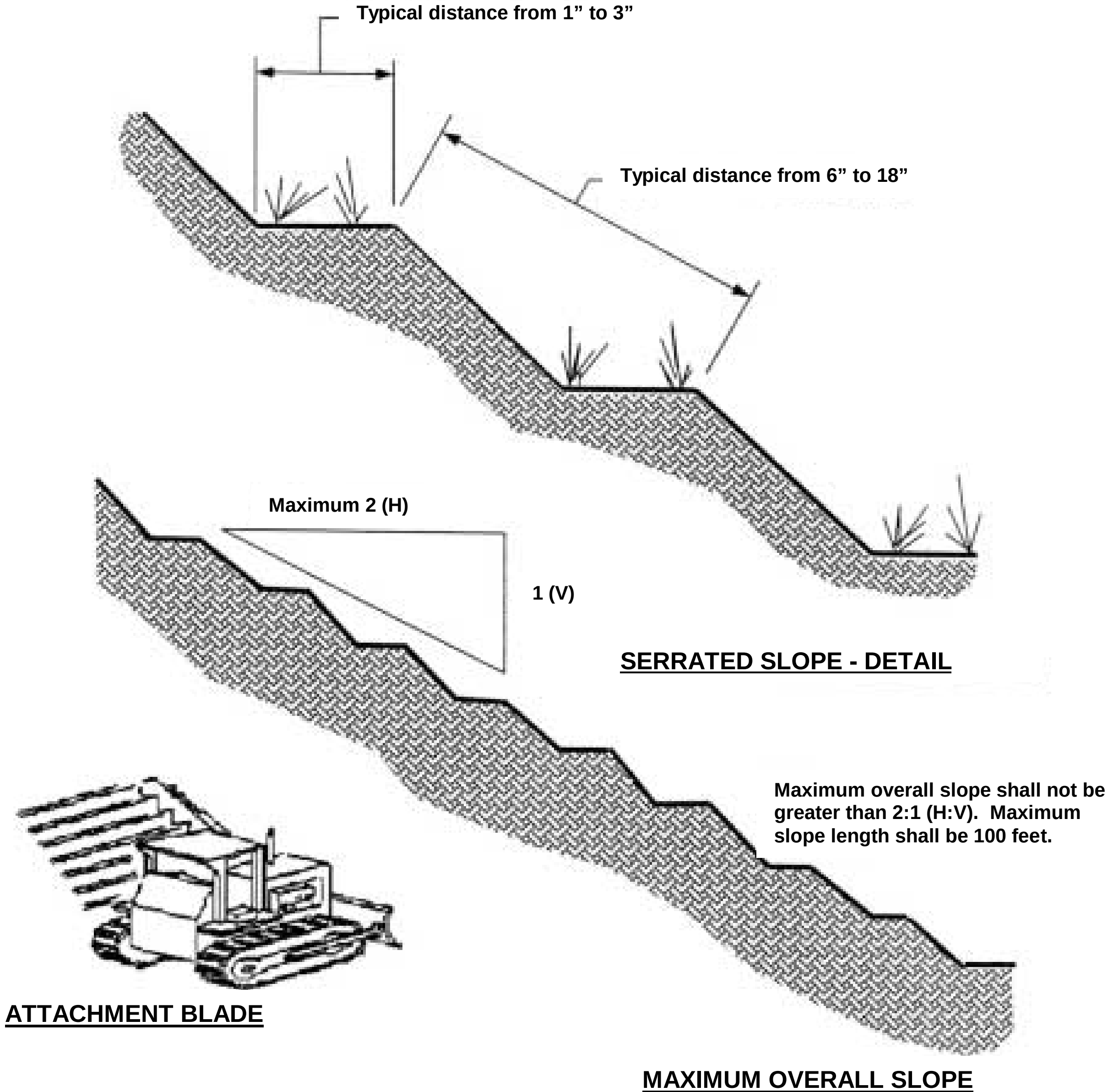
CONTOUR FURROW - SPACING

NOT TO SCALE

Figure 1

Source: Knoxville Engineering Department

Serrated Slope – GT-SE



Note:

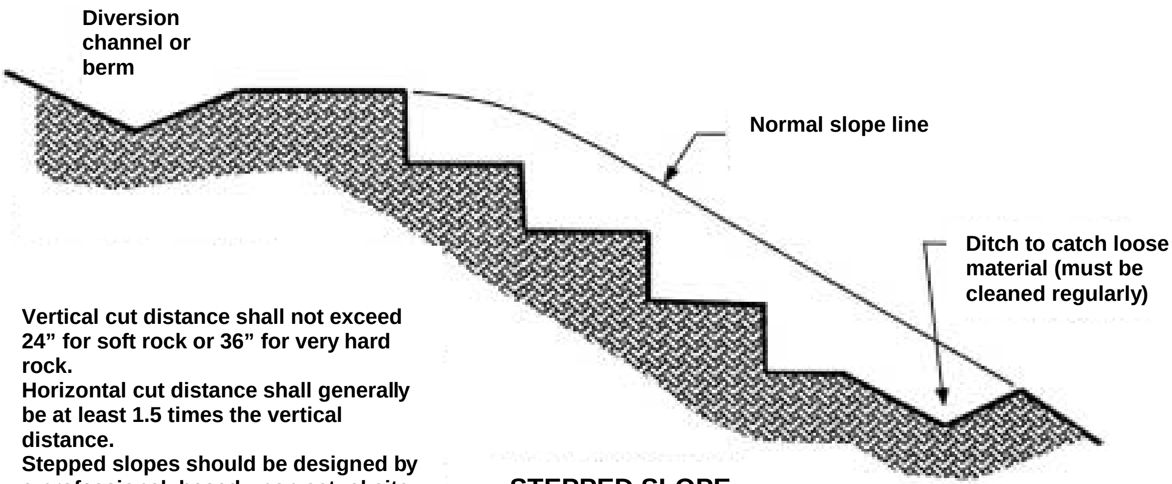
Serrated slopes will catch fertilizer, seed, mulch, and rainfall to reduce storm water runoff.

NOT TO SCALE

Figure 2

Source: Knoxville Engineering Department

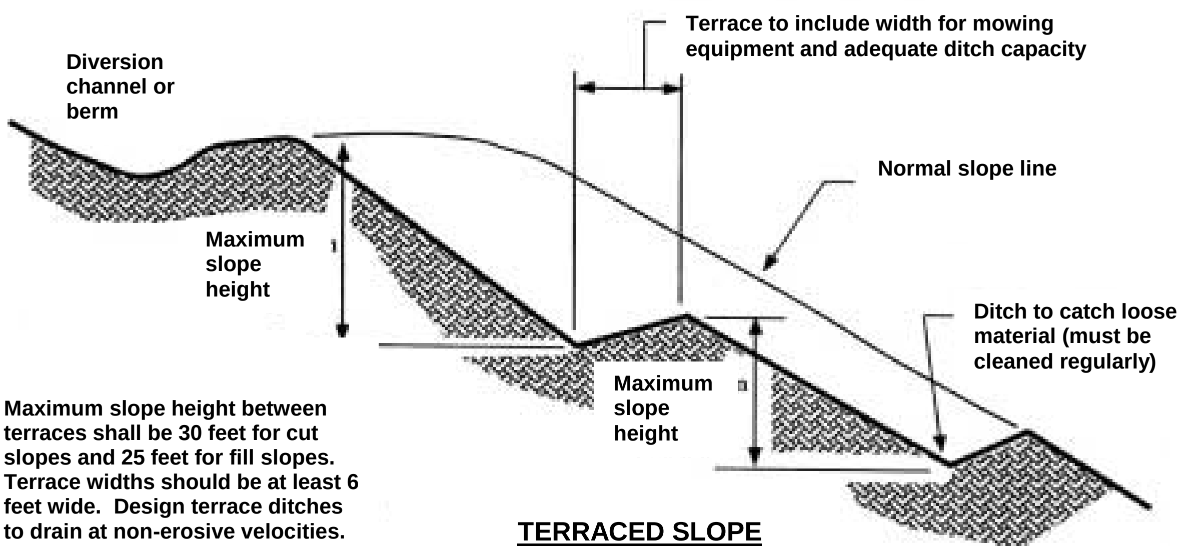
Stepped Slope – GT-ST and Terraced Slope – GT-TE



Notes:

1. Vertical cut distance shall not exceed 24" for soft rock or 36" for very hard rock.
2. Horizontal cut distance shall generally be at least 1.5 times the vertical distance.
3. Stepped slopes should be designed by a professional, based upon actual site conditions.

STEPPED SLOPE



Notes:

1. Maximum slope height between terraces shall be 30 feet for cut slopes and 25 feet for fill slopes.
2. Terrace widths should be at least 6 feet wide. Design terrace ditches to drain at non-erosive velocities.
3. Terraced slopes should be designed by a professional, based upon actual site conditions.

TERRACED SLOPE

NOT TO SCALE

Figure 3

Source: Knoxville Engineering Department

Riprap – RR

DEFINITION

A permanent, erosion-resistant ground cover of large, loose, angular stone with a geotextile or granular underlining.

PURPOSE

Riprap is used to protect culvert inlets and outlets, stabilize stream banks, stabilize drainage channels, and protect slopes and other areas subject to erosion by storm water, where vegetative or geotextile measures are not adequate or appropriate. This practice significantly reduces erosion and sediment movement.

CONDITIONS

Riprap may be used in many different locations and many different ways:

- Along a stream or within drainage channels, as a stable lining resistant to erosion.
- On lakefronts and riverfronts, or other areas subject to wave action.
- Around culvert outlets and inlets to prevent scour and undercutting.
- In channels where infiltration is desirable, but velocities are too excessive for vegetative or geotextile lining.
- On slopes and areas where conditions may not allow vegetation to grow.

Riprap protection of banks and channels of streams, rivers, and lakes requires authorization from the Tennessee Division of Water Pollution Control and United States Army Corps of Engineers. **For more information, see Appendix C and: http://www.state.tn.us/environment/permits/arap.htm**

DESIGN CRITERIA

Riprap applications for channel or slope stabilization should be designed by a professional familiar with the design of storm water conveyance structures.

Stone riprap can either be placed as machine-graded riprap (layers that can be placed by machine and then compacted) or as rubble (large pieces of rock that are placed by hand). Graded riprap is often used for channel linings because it is flexible and can be compacted to a dense structure without manual sorting or placement.

Rubble-stone riprap can be used for an attractive landscaped appearance but lacks flexibility to adapt to settlement, washing out of material, burrowing animals, etc. Hand placed riprap is typically two-dimensional. Each piece is “keyed” into each other and the displacement of one piece may lead to the failure of surrounding pieces. Machine placed riprap layers are typically thicker, providing more structural integrity.

Riprap should be used only when other methods of protection or stabilization are not appropriate. Erosion control matting, geotextiles, and flexible mattresses are examples of geosynthetics that provide an alternative to channels lined with riprap or concrete. Some alternatives to riprap for slopes include surface roughening, vegetation, terracing, and mulching as found elsewhere in this manual.

As a rough guideline, riprap can be specified for a channel design flow velocity that is over 5 feet per second (approximate upper limit of most vegetative channel linings). The upper limit for design flow velocity of a riprap channel lining depends primarily on the size of riprap specified and methods used for securing riprap material in place. Sound engineering practice should be used when considering flow velocity in the design of channels. Graded machined riprap is usually less expensive to install than hand-placed riprap and tends to be more flexible in case of settlement or movement.

CONSTRUCTION SPECIFICATIONS

Quality of Stone: Riprap should generally consist of machined shot rock that is angular and clean. Do not use rounded stones or cobbles for riprap (although cobble stones may be used in grouted channels for architectural appearances). Riprap should not contain sand, dust, organic material, excessive cracks, mineral lenses and intrusions, or other impurities.
Riprap is usually solid durable limestone rock, which is generally resistant to erosion and to normal stream chemistry. Riprap material that is of questionable origin should be given a sodium sulfate soundness test to determine its durability. Riprap material should have a specific gravity of at least 2.5.

Gradation: Different classes of machined riprap are shown in Table 1 taken from the TDOT Standard Specifications for Road and Bridge Construction. Gradations are commonly specified in terms of a specified percentage by weight being smaller than a diameter. For example, TDOT calls for Class B riprap to have a D_{20} of at least 6 inches. This means that for Class B riprap, 20% of the stones, by weight, would be 6 inches in diameter or larger. D_0 would be the smallest allowable size and D_{100} would be the largest allowable size for any specified gradation.

Other types of riprap materials are shown in Table 2. Rubble-stone riprap can be very attractive as well as functional, but requires a great deal of hand labor and time. Manufactured concrete products such as interlocking blocks, articulated blocks, and revetment mattresses can resist very high flow velocities and are usually designed to be flexible for handling settlement and subgrade irregularities. Sacked riprap (essentially a concrete lining) is also labor-intensive and expensive to install. Concrete linings are discouraged because they do not allow for wildlife habitats and may contribute to downstream drainage problems such as high storm water velocities.

For smaller aggregates (less than 2 inches across), gradation is normally determined by mechanically shaking several pounds of material through a set of progressively smaller sieves. Then it can be stated that a certain percentage (by weight) is finer than a particular sieve with a defined opening size, which is then equated with an average diameter. However, riprap material cannot be mechanically shaken through sieves and thus it is more difficult to quantify the average size. The different classes of aggregates are shown in Table 3 and are taken directly from the TDOT Standard Specifications for Road and Bridge Construction.

Machined Riprap Specifications

Class A-1	Class A-3	Class B	Class C
2" to 15" diameter (0.5 to 169 lbs) Dumped	2" to 6" diameter (0.5 to 11 lbs) Dumped	3" to 27" diameter (1.5 to 985 lbs) Dumped	5" to 36" diameter (6 to 2335 lbs) Dumped
20% by weight shall be at least 4" size (3 lbs) Typical thickness is 18" with surface tolerance of 3"	20% by weight shall be at least 4" size (3 lbs) Typical thickness is 12" with surface tolerance of 2"	20% by weight shall be at least 6" size (11 lbs) Typical thickness is 30" with a surface tolerance of 4"	20% by weight shall beat least 9" size (36 lbs) Typical thickness is 42" with a surface tolerance of 6"

Table 1

Non-Machined Riprap Specifications

Rubble-stone (plain)	Rubble-stone (grouted)	Concrete blocks	Sacked riprap (sand-cement)
Min 2" diameter (min 0.5 lbs) Placed by hand	Min 2" diameter (min 0.5 lbs) Placed by hand	Rectangular shapes Placed by hand	Approx 1 cubic ft (approx. 100 lbs) Placed by hand
80% by weight shall be at least 10" in any dimension (prefer rectangular) Remainder is 2" to 4" size for chinking	80% by weight shall be at least 10" in any dimension (prefer rectangular) Remainder is 2" to 4" size for chinking	Class A concrete with 3000 psi 28-day strength Various thickness from 4" upwards	Sacks should be cotton or jute cloth that retains sand and dry cement mix Mix 1 bag cement (94 lbs) with 5 cubic feet of sand
Typical thickness is 12" with surface tolerance of 2"	Typical thickness is 12" with surface tolerance of 2"	Design and install per manufacturer's recommendations	Typical thickness is 10" with a surface tolerance of 2"

Table 2

Source: TDOT Standard Specifications for Road and Bridge Construction

Machined Aggregate Specifications

Size number	1	2	24	3	357
Nominal size square openings	90 to 37.5 mm (3 1/2" to 1 1/2")	63 to 37.5 mm (2 1/2" to 1 1/2")	63 to 19 mm (3 1/2" to 3/4")	50 to 25 mm (2" to 1")	50 to 4.75 mm (2" to No. 4)
Size number	4	467	5	56	57
Nominal size square openings	37.5 to 19 mm (1 1/2" to 3/4")	37.5 to 4.75 mm (1 1/2" to No. 4)	25 to 12.5 mm (1" to 1/2")	25 to 9.5 mm (1" to 3/8")	25 to 4.75 mm (1" to No. 4)
Size number	6	67	68	7	78
Nominal size square openings	19 to 9.5 mm (3/4" to 3/8")	19 to 4.75 mm (3/4" to No. 4)	19 to 2.36 mm (3/4" to No. 8)	12.5 to 2.36 mm (1/2" to No. 4)	9.5 to 2.36 mm (1/2" to No. 8)
Size number	8	89	9	10	
Nominal size square openings	9.5 to 1.18 mm (3/8" to No. 8)	4.75 to 1.18 mm (3/8" to No. 16)	4.75 to 1.18 mm (No. 4 to No. 16)	4.75 mm (No.4 to No.100)	

Table 3

Source: TDOT Standard Specifications for Road and Bridge Construction

Geotextile: A geotextile should be placed beneath riprap to maintain separation from underlying soils. It is also necessary within stream channels to avoid migration of fine-grained soils from the subgrade into the riprap. In particular, use geotextile at the inlet and outlet of culverts, where turbulence is normally expected. Refer to the specification **Geotextiles - GE**

Granular Filter: A layer of aggregate or sand can also be placed beneath riprap to maintain separation from underlying soils, either in addition to geotextile or in place of geotextile. The layer of aggregate or sand acts as a smooth bed to allow easier placement of riprap, and it can be used as a granular filter. The granular filter permits water to drain out or seep through it without allowing the adjacent soil or aggregate to migrate through. In general, a geotextile will perform this function more reliably and with lower installation costs.

A granular filter (Figure 1) should have the following properties with relation to the base soil underneath:

1. D_{15} of filter must not be more than five times D_{85} of base.
2. D_{15} of filter must not be less than five times D_{15} of base.
3. D_{15} of filter must not be more than forty times D_{15} of base.
4. D_{50} of filter must not be more than forty times D_{50} of base.

The relationship of the riprap to an underlying granular filter layer should follow the same filter criteria as between the granular filter and the base soil. In other words, the term "filter" refers to the larger-grained material and the term "base" refers to the smaller-grained material. Due to the many problems associated with carefully placing 6" layers of graded aggregate or sand, the use of geotextile is greatly preferred.

There are many methods available for choosing riprap size, particularly for riprap channel linings. There are methods that make use of only one equation, which can only account for 3 or 4 factors using assumptions and various rule-of-thumb guidelines. There are many methods which try to account for forces and momentum more exactly, with several equations and nomographs being used for factors such as rock specific gravity, stream tractive force, drag force, etc.

Riprap design should be performed by a professional using drainage computations, which consider field conditions, quality of materials, and construction placement. If possible, it is recommended that a few design methods should be used to verify reasonable results.

Riprap for River Shorelines: Riprap for use on river or lake shorelines should be designed to conform to standards by Tennessee Valley Authority (TVA) or the US Army Corps of Engineers.

Riprap for Slopes: Riprap applications for slope stabilization, where wave action or flowing water is not a concern, should be sized for stability. The natural angle of repose is defined as the angle at which material can be placed without sliding downhill due to gravity. Angular riprap or crushed rock typically has an angle of repose in the neighborhood of 40°, so that a slope of 1.5 to 1 is reasonable for most slopes when not subject to flowing water. Rounded stones such as river gravel have a lower angle of repose. See Figure 2 for angle of repose based on average stone size, D_{50}.

The angle of repose does not take into account any external forces (such as vehicles, people, storms, groundwater, earthquakes, or other ground vibrations). Failure will often occur at the interface between two layers, such as on a geotextile filter fabric that is not sufficiently anchored or where hydraulic forces exceed the sheer strength of the base and/or filter layer. A professional engineer should perform slope stability analyses for all sloped areas that are critical or potentially hazardous. See Figure 3 for base of riprap slope protection.

Riprap at Outlets: Design criteria for sizing stone and determining the dimensions and installation of riprap pads used at the outlet of drainage structures are contained in the specification **Storm Drain Outlet Protection - OP**

Typical Granular Filter

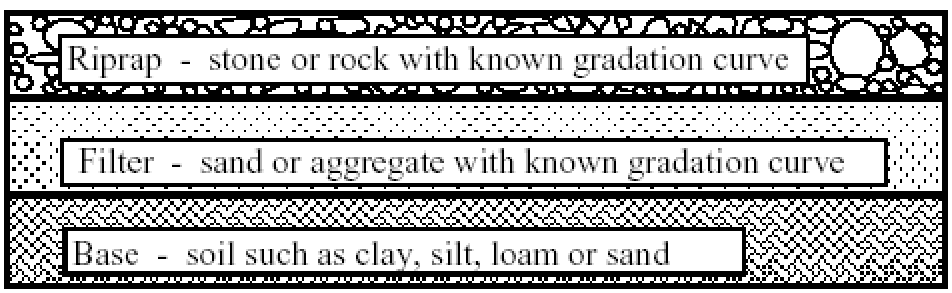


Figure 1

Source: Knoxville Engineering Department

Angle of Repose for Riprap Based on Average Stone Size

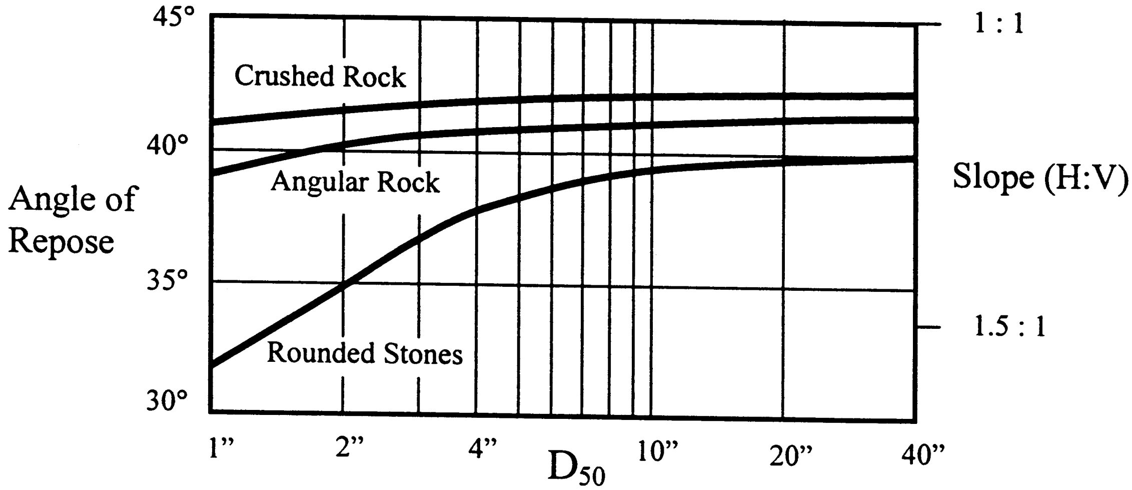


Figure 2

Source: Knoxville Engineering Department

Base of Riprap Slope Protection

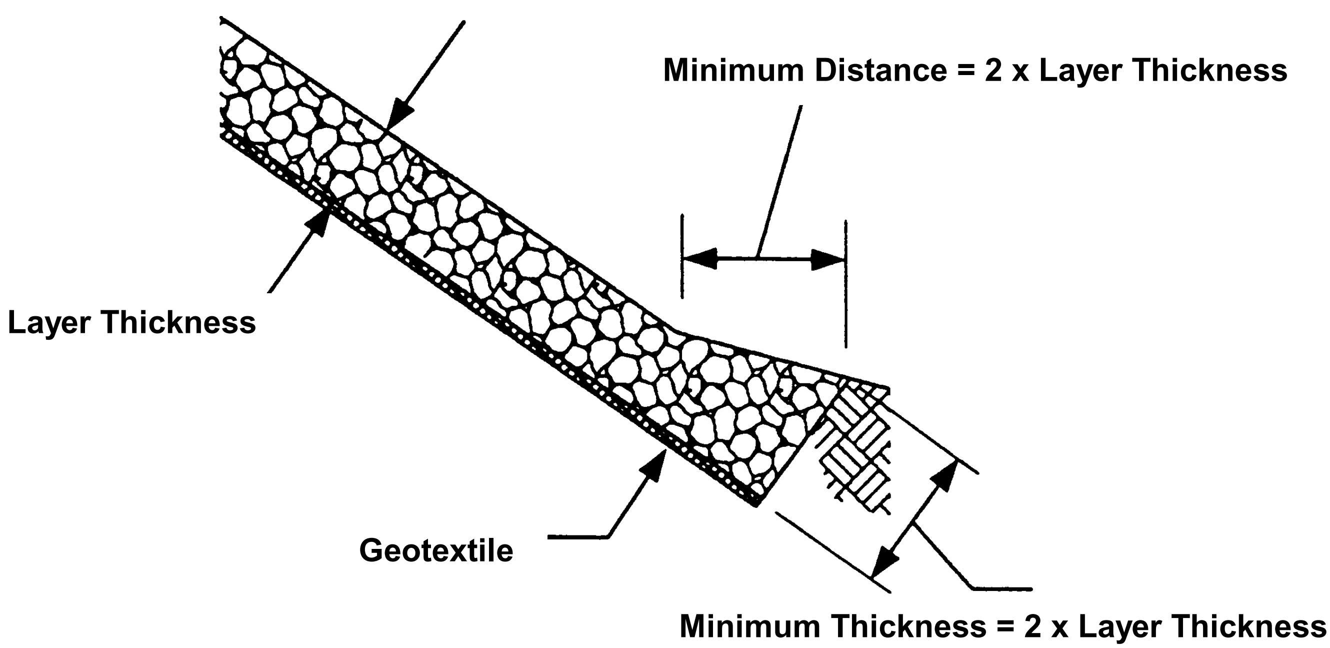


Figure 3

Source: Knoxville Engineering Department

Riprap for Channel Stabilization (HEC-15 design method): The following design method for sizing riprap is taken from Hydraulic Engineering Circular 15, Design of Stable Channels With Flexible Linings, by the Federal Highway Administration (1975). The mean riprap size is computed for tangent sections and curved sections of trapezoidal channels. Drainage computations are used to determine channel shape, channel slope, surface width, and design flow depth by using the Manning's n roughness coefficient equal to:

$$n = 0.0395 \times (D_{50})^{1/6}$$

1. Compute the channel bottom D_{50} riprap size based on the following equation where D_{50} and the maximum design flow depth have the same units (inches or feet) and channel slope is expressed in feet per foot (H:V):

$$\text{Bottom } D_{50} = 12.5 \text{ X depth X Channel Slope}$$

2. If the channel side slopes are steeper than 3:1, then the side slope D_{50} riprap size will be adjusted using the following equation where K_1 is obtained from Figure 4 and K_2 is obtained from an equation:

$$\text{Bottom } D_{50} \times K_1 / K_2 = \text{side slope } D_{50}$$

$$K_2 = (1 - \sin^2(\varphi)/\sin^2(\theta))^{0.5}$$

The side slope D_{50} is the riprap size necessary for the side slopes of tangent sections where side slope is steeper than 3:1 (18.5°), φ is the angle of the side slope in degrees, and θ is the angle of repose in degrees

3. For curved sections of channel, compute the ratio $\triangle_c$ that is the internal angle that differentiates between a short bend and a long bend. The value R_O is the radius of the channel centerline bend, and the value R_D is the average radius of the channel outside bend as computed by the following equation using T (top width of the channel) and B (bottom width of trapezoidal channel):

$$R_D = R_O + 0.25\,(T+B)$$
$$\triangle_C = \cos^{-1}(R_O / R_D).$$

Distribution of Boundary Shear For Trapezoidal Channels

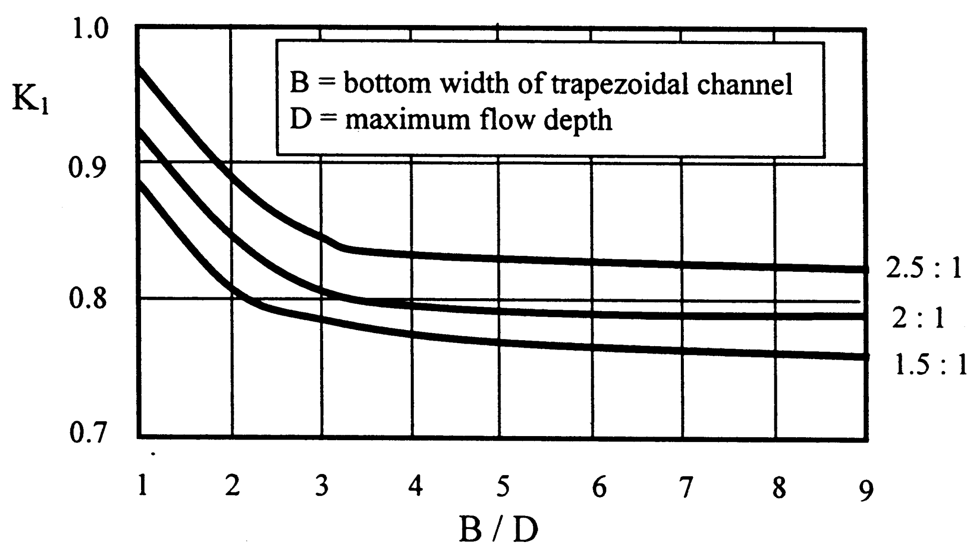


Figure 4

Source: Knoxville Engineering Department

4. Long bend (bend angle $\triangle$ is more than $\triangle_c$): The tangent D_{50} riprap size (from step 1 if side slopes are not steeper than 3:1, or Step 2 if side slopes are steeper than 3:1) will be adjusted using the coefficient K_3 that is obtained from an equation with V being the average velocity (using Manning's flow equation):

$$\text{Curved } D_{50} = K_3 \times \text{tangent } D_{50}$$
$$K_3 = 4 \times V^2 / R_D$$

5. Short bend (bend angle $\triangle$ is less than $\triangle_c$): The tangent D_{50} riprap size (from Step I if side slopes are not steeper than 3:1, or Step 2 if side slopes are steeper than 3:1) will be adjusted using the coefficient K_4 that is obtained from an equation using K_3 as computed above:

$$\text{Curved } D_{50} = K_4 \times \text{tangent } D_{50}$$
$$K_4 = I + (K_3 - 1)\ (\triangle / \triangle_c)$$

The selection of a mean riprap size D_{50} will basically specify a gradation curve. The maximum riprap size should be 1.5 times the D_{50} riprap size. The riprap layer thickness should be approximately 1.7 to 2.0 times the D_{50} riprap size, in accordance with the TDOT riprap classifications in Table 1.

The minimum freeboard for a riprap channel should generally be at least 6 inches, depending upon the type of computations and potential for damage. Always provide additional freeboard at culvert inlets and outlets, areas of potential turbulence, changes in slope or direction, etc. Superelevation of the flow surface may occur on the outside bank of a channel bend. The amount of superelevation, $\triangle_Y$, can be estimated using the following equation where g is equal to 32.2 feet per second per second and the other terms have already been defined:

$$\triangle_Y = (V^2\ T) / (g\ R_O)$$

INSTALLATION

Installation of riprap should be accomplished within a short time frame (1 or 2 days) to minimize potential for damage from storm water runoff.

General Subgrade Preparation

1. The area should be cleared of trees, brush, vegetation, unsuitable soils, and graded. Access for equipment that will be necessary for earthwork and handling of large rocks should be provided.

2. The subgrade should be prepared to the specified depth necessary for installation of riprap. Compact subgrade firmly to prevent slumping or undercutting. Excavate anchor trenches as necessary for installation of geotextile filter fabric.

3. Install geotextile to maintain separation of rock material from the underlying soil. Geotextile should be placed so that it is not stretched tight, and it conforms closely to the subgrade. Secure filter fabric by using anchor trenches, stakes, staples, sewing or any other means necessary according to manufacturer's recommendations.

4. Place a layer of aggregate or sand (if specified by design for use as a bedding layer or as a granular filter) so that the layer is smoothly graded and well-compacted. A typical layer of aggregate or sand is 4 inches thick when used only as a bedding material. A granular filter of aggregate or sand is usually 6 inches thick.

Rubble-Stone Riprap: Rubble-stone riprap is usually placed as one layer (12" deep), two layers (2 @ 6" deep), or an interlocking mixture of one and two layers. Rubble-stone riprap should be hand placed so that the stones are close together, are staggered at all joints as far as possible, and are placed so as to reduce the voids to a minimum. The larger rocks should be thoroughly chinked or anchored in place by using I" to 3" stones or aggregate by placing over the surface and compacting in any manner practical.

When rubble-stone riprap is constructed in layers, the layers should be thoroughly tied together with large stones protruding from one layer into the other. The average depth is usually determined by frequent measurements throughout installation. Any change in thickness should be accomplished gradually.

Installation of grouted rubble-stone riprap includes hand placement of large rocks, chinking with smaller rocks and aggregate, filling with grout, surface finishing, and curing.

Machined Riprap: Machined riprap material is generally dumped and placed by the use of appropriate power equipment. Placement should avoid segregating material by minimizing drop heights and by dumping material in large quantities. Riprap is then graded and compacted (using hand or mechanical tamping) to produce a surface uniform in appearance. Handwork may be required to correct irregularities. Place riprap carefully to avoid puncturing or displacing geotextile fabric.

Typical layer thickness and allowable surface tolerances are shown in Table 1. Class A-2 machined riprap is the same as Class A-1 riprap except that the depth may be decreased to 12 or 15 inches when placed by hand in accordance with rubble-stone installation procedure. Other classes of hand-placed riprap are listed in Table 2.

INSPECTION

The final step in riprap installation is to verify proper construction methods are used and that the specified gradation was installed. Visually inspect machined riprap to ensure that at least 20 percent of surface area consists of the D_{20} stone sizes specified within the materials section. Check that 50 percent of the surface area consists of stones no smaller than one-half of the maximum size specified.

Table 4 provides a rough guide to estimating the weight and equivalent diameter size of riprap material. A unit weight of 165 pounds per cubic foot is the same as a specific gravity of 2.65 with respect to water. Rectangular dimensions in a ratio of 3:2:I are also listed as a frame of reference.

MAINTAINANCE

Riprap slopes and channel linings should be checked after major storm events for slumping, displacement, scour or undermining of riprap. Replace or reposition riprap as necessary, making a note of any damage for future reference.

Weight and Size Equivalents of Riprap
(assuming a unit weight of 165 pounds per cubic foot)

Weight	Equivalent diameter (spherical)	Rectangular dimensions (assuming 3:2:1 ratio)
1 pound	2.7 inches	3.6" x 2.4" x 1.2"
2 pounds	3.4 inches	4.6" x 3.0" x 1.5"
5 pounds	4.6 inches	6.2" x 4.1" x 2.1"
10 pounds	5.8 inches	7.8" x 5.2" x 2.6"
20 pounds	7.4 inches	9.8" x 6.5" x 3.3"
30 pounds	8.4 inches	11.2" x 7.5" x 3.7"
40 pounds	9.3 inches	12.4" x 8.2" x 4.1"
50 pounds	10.0 inches	13.3" x 8.9" x 4.4"
75 pounds	11.4 inches	15.2" x 10.1" x 5.1"
100 pounds	12.6 inches	16.8" x 11.2" x 5.6"
150 pounds	14.4 inches	19.2" x 12.8" x 6.4"
200 pounds	15.9 inches	21.2" x 14.1" x 7.1"
250 pounds	17.1 inches	22.8" x 15.2" x 7.6"
300 pounds	18.2 inches	24.2" x 16.1" x 8.1"
500 pounds	21.5 inches	28.7" x 19.1" x 9.6"

Table 4

Source: Knoxville Engineering Department

Sediment Basin – SB

DEFINITION

A temporary basin consists of an embankment constructed across a drainage way, or of an excavation that creates a basin, or by a combination of both. A sediment basin typically consists of an impoundment, a dam, a riser pipe outlet, and an emergency spillway. The size of the structure will depend upon the location, size of the drainage area, soil type, land cover/use, rainfall amount, and any unique site conditions favorable to producing high runoff volume, velocity, or sediment.

PURPOSE

A sediment basin is used to retain runoff waters and trap sediment from disturbed areas to protect properties and waters below the installation from damage by excessive sedimentation and debris. The water is temporarily stored and the bulk of the sediment carried by the water falls out of suspension and is retained in the basin, while the water is slowly released over a period of time.

CONDITIONS

This practice is required by permit at locations within construction sites where the total disturbed drainage area at any given time is at least ten (10) acres. Sediment basins may also be used for drainages smaller than ten acres, however they are not mandatory. There must be sufficient space and appropriate topography for the construction of a temporary impoundment. Specifications described in this standard apply to temporary installations that are to be removed within 18 to 30 months and where the total drainage area does not exceed 50 acres. By virtue of their potential to impound and release large volumes of water, the design of sediment basins is required to be completed by professionals trained in the design of impoundment structures, and in accordance with good engineering practices.

DESIGN CRITERIA

Compliance with Laws and Regulations: Sediment basin design and construction shall comply with all applicable state and local laws, ordinances, permit requirements, rules, and regulations. Basins shall be constructed according to the approved SWPPP unless modified by the engineering design professional. Additional regulations apply if vertical height of dam from downstream toe to crest of embankment exceeds 20 feet. Refer to "Embankment Cross-Section" later in this section.

Location: To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. **Runoff from undisturbed areas should be diverted away from or around the disturbed areas and the basin.** The best locations are generally low areas and natural swales or drainageways below disturbed areas. It is recommended that the basin be located at least 50 feet outside the designated floodway or 25 feet from the top of bank of small streams or as otherwise required by local ordinance, whichever is greater. Basin efficiency can be improved by the use of diversions (refer to **Diversion - DI**) and by introducing chemical coagulants and coagulant aids (refer to **Polyacrylamide - PAM**). **Under no circumstance shall a basin be located in a stream or in any waters of the state.** Instead, the basin should be located to trap sediment-laden runoff before it enters a stream. The basin should not be located where its failure would result in the loss of life or interruption of the use or service to public utilities or roads.

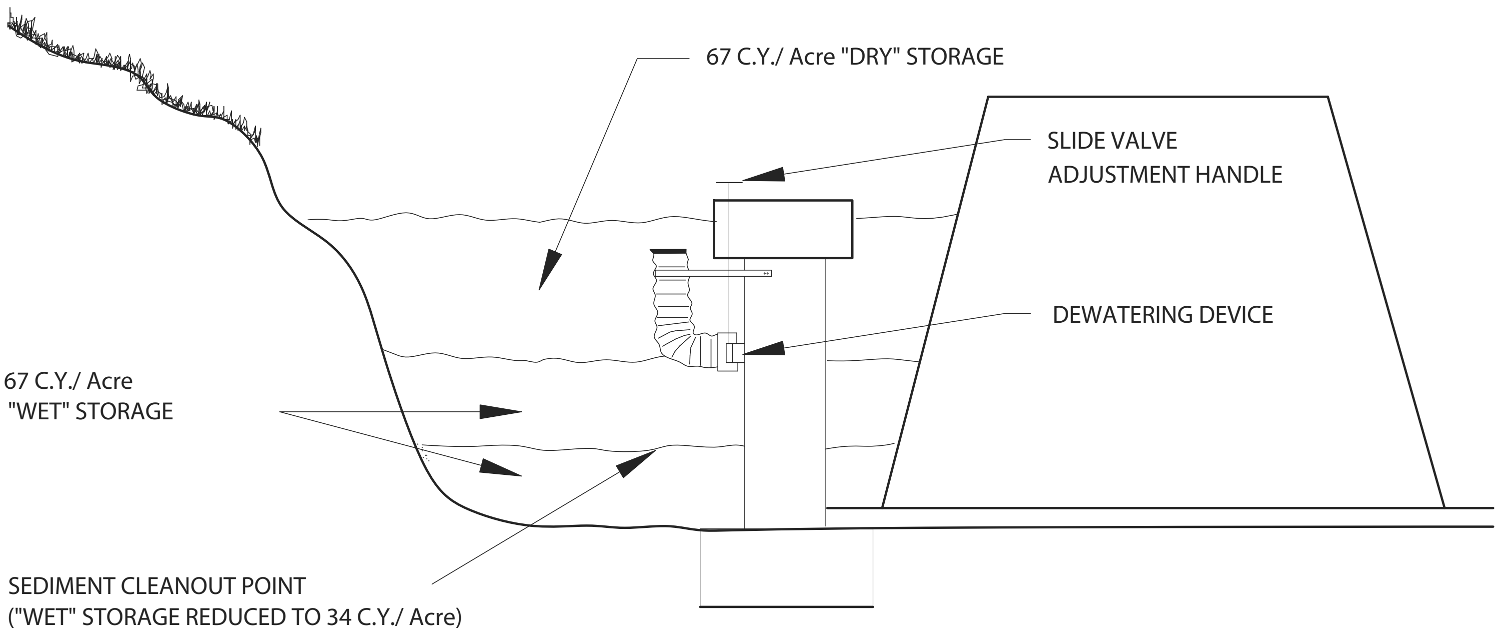
Maximum Drainage Area: The maximum allowable total drainage area (disturbed and undisturbed) feeding into a temporary sediment basin is 50 acres. It is recommended that when the drainage area to any one temporary basin exceeds 25 acres, an alternative design procedure that more accurately defines the specific hydrology, sediment loading, hydraulics of the site, and the control measures in use be utilized to perform design calculations. The design criteria in this manual do not generate hydrographs, estimate sediment erosion and delivery rates, provide hydraulic routing, or predict sediment capture efficiency. More rigorous and accurate design considerations, which are more site-specific than those in this manual, are acceptable and encouraged with any size basin.

Effectiveness and Volume: Sediment basins constructed according to these standards are, at best, 50 to 70 percent effective in trapping sediment that flows into them during large storm events, or during periods of minimal vegetative cover at a construction site. The performance of any sediment pond depends on several factors: (1) size and shape of the basin, (2) soil properties, (3) runoff volume and flow, (4) water chemistry, (5) permanent vs. dry pond design, and other factors. It should be understood that a sediment basin is a temporary, but defensive measure, and should be made functional before any upslope land disturbance takes place in order to keep sediment from escaping the site and washing into storm sewers, and filling streams and waterways. Basins should always be used in conjunction with primary erosion control and stabilizing practices (as found throughout this manual) such as temporary seeding, mulching, diversion dikes, etc. designed to prevent or reduce the possibility of soil from being eroded in the first place.

In order to maximize trapping and retaining the incoming sediment, the basin should have a permanent pool, or wet storage component and a dry storage component that dewaters over time. The volume of the permanent pool (needed to protect against re-suspension of sediment and to promote better settling conditions between runoff events) must be at least 67 cubic yards (1809 cubic feet) per acre of drainage area and the volume of dry storage above the permanent pool (needed to prevent "short-circuiting" of the basin during larger storm events) must be at least an additional 67 cubic yards (1809 cubic feet) per acre of drainage area. The total storage volume of the basin at the principal (service) spillway riser crest would, therefore, be a minimum of 134 cubic yards (3,618 cubic feet) per acre of drainage area (see Figure 1).

When computing the number of acres draining into a common location, it is not necessary to include flows from offsite areas and runoff from undisturbed or permanently stabilized areas where such flows are diverted around both the disturbed area and the sediment basin. Otherwise, the calculations for determining basin size should include the entire drainage area, disturbed and undisturbed.

Minimum Storage Volume and Sediment Cleanout Point



Source: VA DSWC

Figure 1

The volume of the permanent pool shall be measured from the lowest point of the basin to the bottom of the dewatering device. This device should be installed at the elevation corresponding to one half the total storage volume. The volume of the active or drawdown zone shall be measured from the elevation of the permanent pool to the crest of the principal (service) spillway riser pipe. Sediment should be removed from the basin when the volume of the permanent pool has been reduced by one half. In no case shall the sediment cleanout level be higher than one foot below the bottom of the dewatering device for the drawdown zone. The elevation of the sediment cleanout level should be calculated and clearly marked on the plans and the riser. Since this part of the riser normally will be under water, a mark should appear above the permanent pool a measured distance above the cleanout elevation to provide a reference from which to measure the sediment depth.

The above volume requirements should be regarded to be minimum criteria and may be modified at the discretion of the engineering design professional to protect critical aquatic resources and safety/health of the public. It is noted that undisturbed areas can contribute significant amounts of runoff that can reduce the efficiency of a sediment basin. The following conditions and circumstances need to be considered in determining whether or not the basin volume would need to be increased:

- Highly erodible soils
- Steep upslope topography
- Space-limiting basin geometry (depth and/or shape)
- Degree to which off- and/or on-site runoff is diverted from contributing undisturbed areas
- Sediment cleanout schedule
- Degree to which chemical flocculent agents are added to inflowing runoff
- Extent to which other erosion and sediment control practices are used
- Critical downstream conditions

For drainage locations which serve 10 or more disturbed acres at one time and where a temporary sediment basin is not feasible, multiple, smaller basins and/or sediment traps must be used. The total trapping capacity of these must have an equivalent storage of 134 cubic yards (3618 cubic feet) of runoff per acre.

Note: There are 27 cubic feet per cubic yard. Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

or

number of cubic feet / 27= number of cubic yards

While attempting to attain the desired storage capacities, efforts should be made to keep embankment heights to a minimum. When site topography permits, the designer should give strong consideration to the use of excavation to obtain the required capacity and to possibly reduce the height of the embankment. This excavation can be designed in a manner which creates a wet storage forebay area or which increases the storage capacity over the entire length of the basin.

Basin Shape: It is important that the designer of a sediment basin incorporate features to maximize detention time within the basin in order to improve its trapping efficiency. Suggested methods of accomplishing this objective are:

- Recommended design effective length to width ratio is 4:1, but not less than 2:1, where length is the distance between the inlet and outlet.
- A wedge shape with the inlet located at the narrow end - ideally, the shape would be symmetrical about the pond's central axis formed by the inlet - riser - center of the dam.
- Installation of baffles or diversions.

The purpose of having a length to width ratio of at least 2:1 is to minimize the "short-circuiting" effect of the sediment-laden inflow to the riser and thereby increasing the effectiveness and efficiency of the sediment basin. Having a symmetrical basin about the central axis from the inlet to the riser tends to reduce dead or ineffective space.

The length of the flow path (L) is the distance from the point of inflow to the riser outflow point. The point of inflow is the point that the waste stream enters the active (sometimes called "normal") pool, created by the elevation of the riser crest. The pool area (A) is the area of the active pool. The effective width (We) is equal to the area (A) divided by the length (L). The length to width ratio (L:W) is found by the equation:

$$L:W = L/We = L/(A/L) = L^2/A$$

The designer is encouraged to locate all inflows at or near the point of the wedge. However, where there is more than one inflow point and where circumstances preclude this ideal arrangement, any inflow point which conveys more than 30 percent of the total peak inflow rate shall meet the above length-width ratio criteria. Ponds whose L:W ratios are less than 1, even if enhanced with baffling, are not permitted.

For ponds having L:W ratios less than 4:1, construction should consist of two wetpool cells using a separation berm, as shown in Figure 2. The first (upper) wetpool cell volume should hold between 25% to 35% of the total wetpool volume. Ponds with L:W ratios equal to or greater than 4:1 are suggested to follow this design, but may be single cell construction.

Baffles: The required basin shape should be obtained by proper site selection and by excavation to reduce dead storage and to maximize sediment removal efficiency. Where less than ideal conditions exist, a baffle may be constructed in the basin. The purpose of the baffle is to increase the effective flow length from the inflow point(s) to the riser. Baffles shall be placed mid-way between the inflow point and the riser. The baffle length shall be as required to achieve the minimum 2:1 length-width ratio at less than ideal site conditions. The effective length (Le) shall be the shortest distance the water must flow from the inflow point around the end of the baffle to the outflow point.

Then:

$$L:W = Le/We = Le^2/A$$

Three baffle examples are shown in Figure 3. Note that that for the third baffle case:

$$L = L_1 + L_2$$

The baffle material should be outdoor grade and weather resistant. The baffles should be placed in such manner to minimize interference with basin cleaning. Construction should be modular for easy maintenance and convenient replacement in event of damage from cleaning or from deterioration. The baffles should be inspected frequently for tears or breaks from weathering, high flows, and from cleaning damage. Damaged baffling should be replaced or repaired immediately.

The dimensions necessary to obtain the required basin volume and surface area shall be clearly shown on the plans to facilitate plan review and inspection.

Multiple Use: Sediment basins may remain in place after final site stabilization is completed to serve as permanent storm water management structures. Because the most practical location for a sediment basin is often the most practical location for a storm water management basin, it is often desirable to utilize these structures for permanent storm water management purposes. It should be noted, however, that in most cases, a typical structure's outlet control system would vary during construction and post-construction periods. Care must be taken to avoid constructing an outlet control system, which will achieve the desired post-construction quantity or quality control but will not provide the necessary facility for the containment and settling of sediment-laden construction runoff. Notably, the design for such permanent flow control ponds is beyond the scope of these standards and specifications.

Access Requirements: Maintenance access road(s) shall be provided to the sediment pond facility for convenient inspection and for access by maintenance and emergency vehicles. An access track around the pond is recommended for convenient removal of sediment from the

Sediment Basin Showing 2 Cells

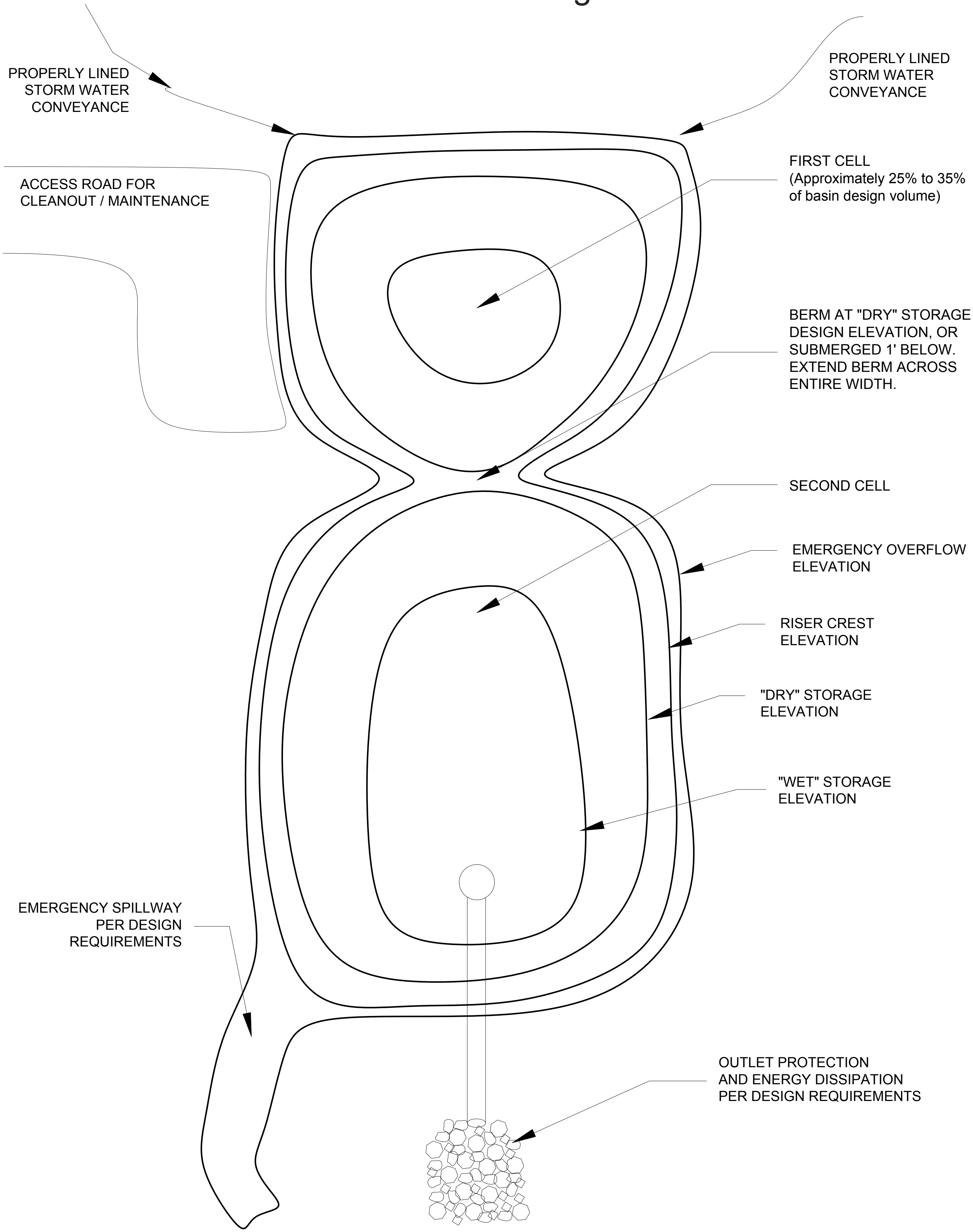
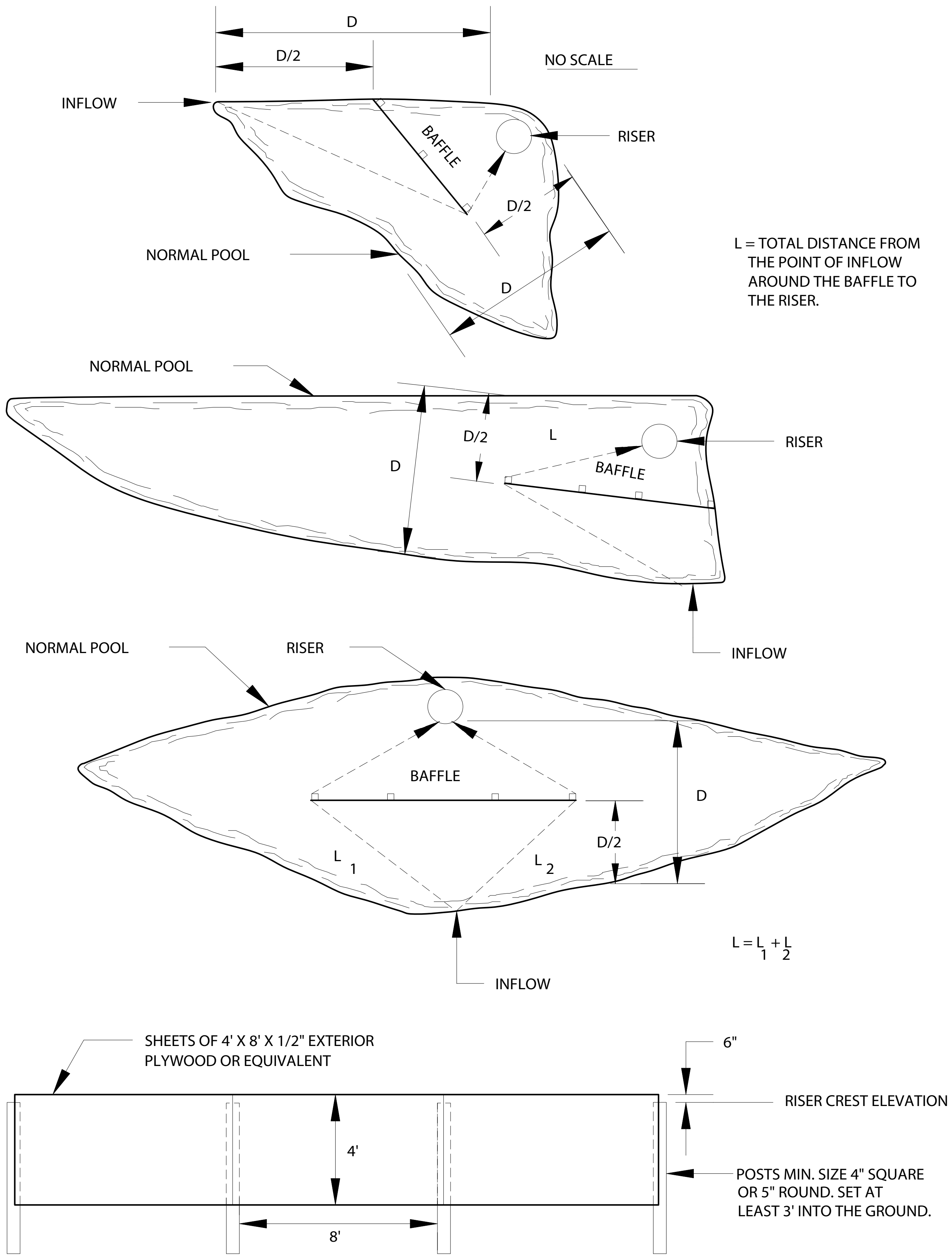


Figure 2

Baffle Locations in Sediment Basins



Source: US NRCS

Figure 3

pond or pond cells with appropriate equipment. An access ramp into the pond itself is discouraged because of the potential for creating equipment-generated rutting and stabilization problems.

Embankment Cross-Section: The height of the embankment dam is measured from its crest down to the lowest point of natural grade (at the downstream toe of the embankment). For dam heights less than 10-feet, the embankment must have a minimum top width of 6 feet, and the side slopes must be 2:1 or flatter to permit access and maintenance. In the case of an embankment 10 to 14 feet in height, the minimum top width shall be 8 feet and the side slopes 2.5:1 or flatter. For 15 to 19 high embankments, the top width must be 10 feet with maximum side slopes of 2.5:1. Embankments must comply with the Tennessee Safe Dams Act of 1973, as amended if either of the following two conditions exist: (a) the embankment is twenty feet or more in height, or (b) the impoundment will have a capacity, at maximum water storage elevation, of thirty (30) acre-feet (48,400 cy/yds) or more. Any such dam which is equal to or less than six feet in height, regardless of storage capacity, or which has a maximum storage capacity not in excess of fifteen (15) acre-feet (24,200 cy/yds), regardless of height, would not be regulated under the Safe Dams Act. If ponds and dams meet or exceed the criteria mentioned above, permit certificates of construction and operation are required by the Tennessee Dam Safety Office in the Division of Water Supply of the Tennessee Department of Environment and Conservation. Further information on safe dam design standards, regulations, and permit applications is available at the website: http://www.state.tn.us/environment/permits/safedam.htm.

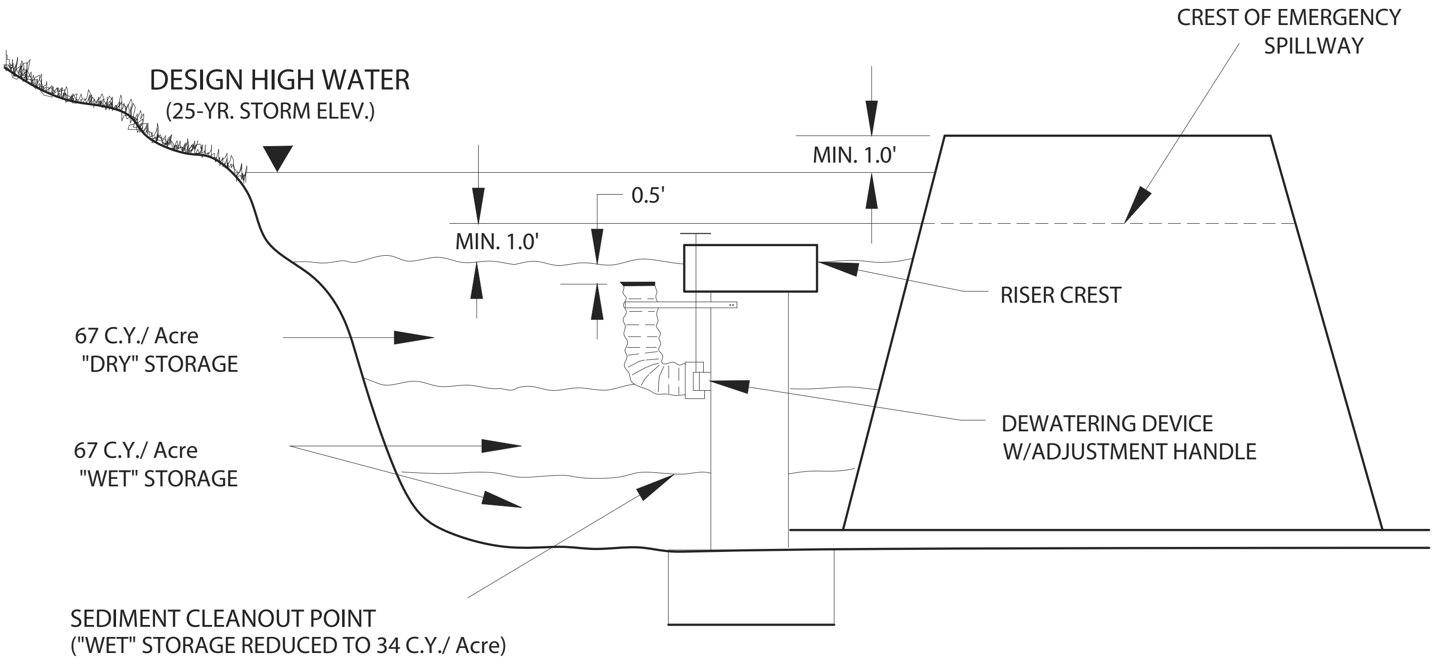
The site foundation for the embankment should be prepared by removing all vegetation, debris, topsoil, and large rocks down to competent material. Embankments should be keyed into the foundation soil with at least a 2-ft x 2-ft. trench. The embankment height should include a 10 percent settlement allowance across the longitudinal axis of the dam. A minimum 1-foot freeboard is required between the maximum design flow water level and top of the dam. (See Figure 4)

Spillways Design: The outlets for the basin should consist of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 25-year 24-hour storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 25-year 24-hour storm. However, an attempt to provide a separate emergency spillway should always be made (refer to "Emergency Spillway" later on in this section) because the principal spillway riser is vulnerable to clogging by debris during high runoff events. Runoff computations shall be based upon the soil cover conditions that are expected to prevail during the life of the basin. In determining total outflow capacity, the flow through the dewatering device cannot be credited when calculating the 25-year 24-hour storm elevation because of its potential to become clogged. However, principal spillway capacity can be credited with the emergency spillway capacity when determining the peak flow and maximum pond elevation from the 25-year 24-hour storm. Incoming flood flow and storage calculations must begin at the elevation of the principal spillway riser crest.

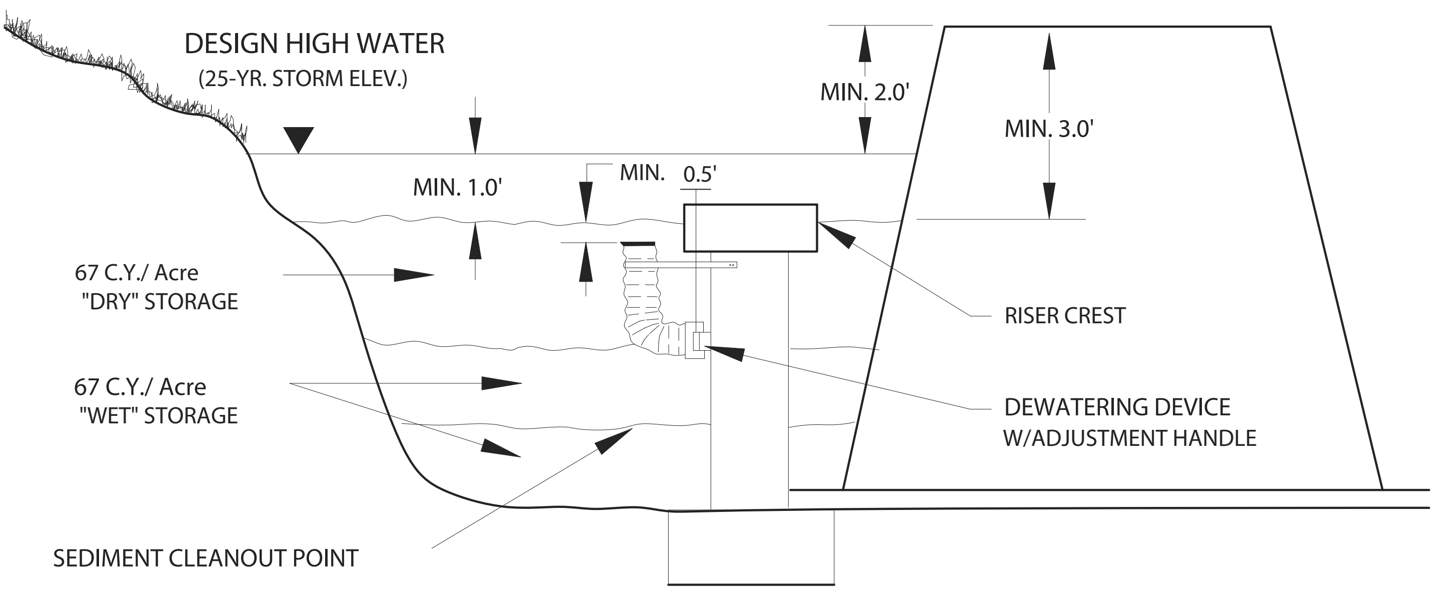
Temporary sediment pond storage and outflow controls are not normally designed to reduce incoming peak flows. Consequently, the spillways designed by the procedures contained in the standard and specification will not necessarily result in any reduction in the peak rate of runoff. If a reduction in peak runoff is desired, the appropriate hydrographs/storm routings should be generated to choose the basin and outlet sizes.

Dewatering: Provisions shall be made to dewater the basin down to the permanent (wet) pool elevation. It is well known that particle characteristics, flow-through velocity, surface loading rate, turbulence levels, sediment concentration and other lesser factors can have a significant effect on the sediment trapping efficiency in a pond. Studies have generally shown that the slower the flow-through velocity and, hence, the

Sediment Basin Schematic Elevations



Design Elevations With Emergency Spillway



Design Elevations Without Emergency Spillway
(Riser Passes 25-YR Event)

Source: VA DSWC

Figure 4

longer the detention storage time in a pond, the greater the sediment removal efficiency. TDEC recommends a 72-hour drawdown time.

Dewatering of the dry storage should be done in a manner that removes the "cleaner" water without removing the potentially sediment-laden water found in the wet storage area or any appreciable quantities of floating debris. An economical and efficient device for performing the drawdown is a "skimmer" type section of perforated vertical tubing, which is connected to and braced to the principal spillway at two locations. A slide gate type of valve is required at the bottom of this tubing for achieving the desired drawdown time and seasonal control. Figure 5 provides a schematic orientation of such a device. Because of the potential for the dewatering device or orifice becoming clogged, no credit should be given for drawdown by the device in the calculation of the principal or emergency spillway locations.

A dewatering operation procedure might be to keep the slide gate valve closed during dry periods, or close it before anticipated precipitation events. Then, during and after the precipitation event, the slide gate valve is manually adjusted to allow the draw down to begin. The amount of adjustment should be determined so that the draw down to the wet pool elevation occurs over a period of 72 hours, as stated above.

Principal (or Service) Spillway: For maximum effectiveness, the principal spillway should consist of a vertical riser pipe or box of corrugated metal or reinforced concrete, with a minimum diameter of 18 inches, joined by a watertight connection to a horizontal drain pipe (barrel) extending through the embankment and discharging beyond the downstream toe of the fill. The riser and all pipe connections shall be completely water tight except for the inlet opening at the top or dewatering openings, and shall not have any other holes, leaks, rips, or perforations. If the principal spillway is used in conjunction with a separate emergency spillway, the principal spillway must be designed to pass at least the peak flow expected from of 2-year 24-hour storm. If no emergency spillway is used, the principal spillway must be designed to pass the entire peak flow expected from a 25-year 24-hour storm. See Figure 6 for details.

Design Elevations: The crest of the principal spillway riser shall be set at the elevation corresponding to the total storage volume required (67 cubic yards/acre wet storage plus 67 cubic yards/acre dry storage = 134 cubic yards/acre). If the principal spillway is used in conjunction with an emergency spillway, this elevation shall be a minimum of 1.0 foot below the crest of the emergency spillway. In addition, a minimum freeboard of 1.0 foot shall be provided between the maximum 25-year pool level and the top of the embankment. If no emergency spillway is used, the crest of the principal spillway shall be a minimum of 3 feet below the top of the embankment; also, a minimum freeboard of 2.0 feet shall be provided between the 25-year pool level and the top of the embankment.

Anti-Vortex Device and Trash Rack: An anti-vortex device and trash rack shall be attached to the top of the principal spillway to improve the flow characteristics of water into the spillway and to reduce the possibility of floating debris from blocking the principal spillway. The anti-vortex device shall be of the concentric type as shown in Figure 7, and designed using the information provided in Table 1.

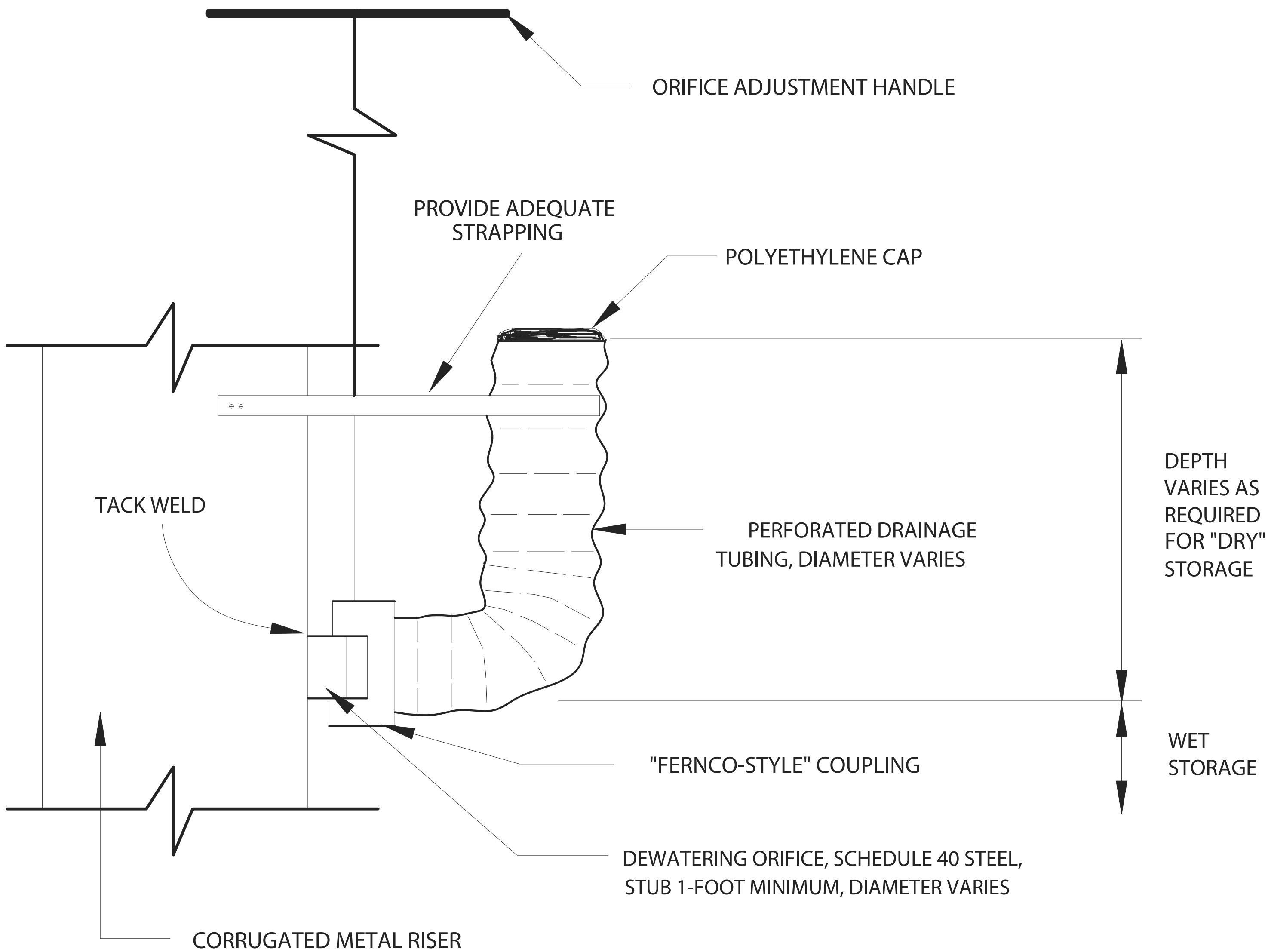
Spillway Foundation: The foundation base of the principal spillway must be firmly anchored to prevent its floating due to buoyancy. If the riser of the spillway is greater than 10 feet in height, computations must be made to determine the anchoring requirements to prevent flotation. A minimum factor of safety of 1.25 shall be used (downward forces = 1.25 x upward forces).

For risers 10 feet or less in height, the anchoring may be done in one of the two following ways:

1. A concrete base 18 inches thick and twice the width of riser diameter shall be used and the riser embedded at least 6 inches into the concrete. See Figure 8 for details.

2. A square steel plate, a minimum of 1/4-inch thick and having a width equal to

Recommended Dewatering System for Sediment Basins

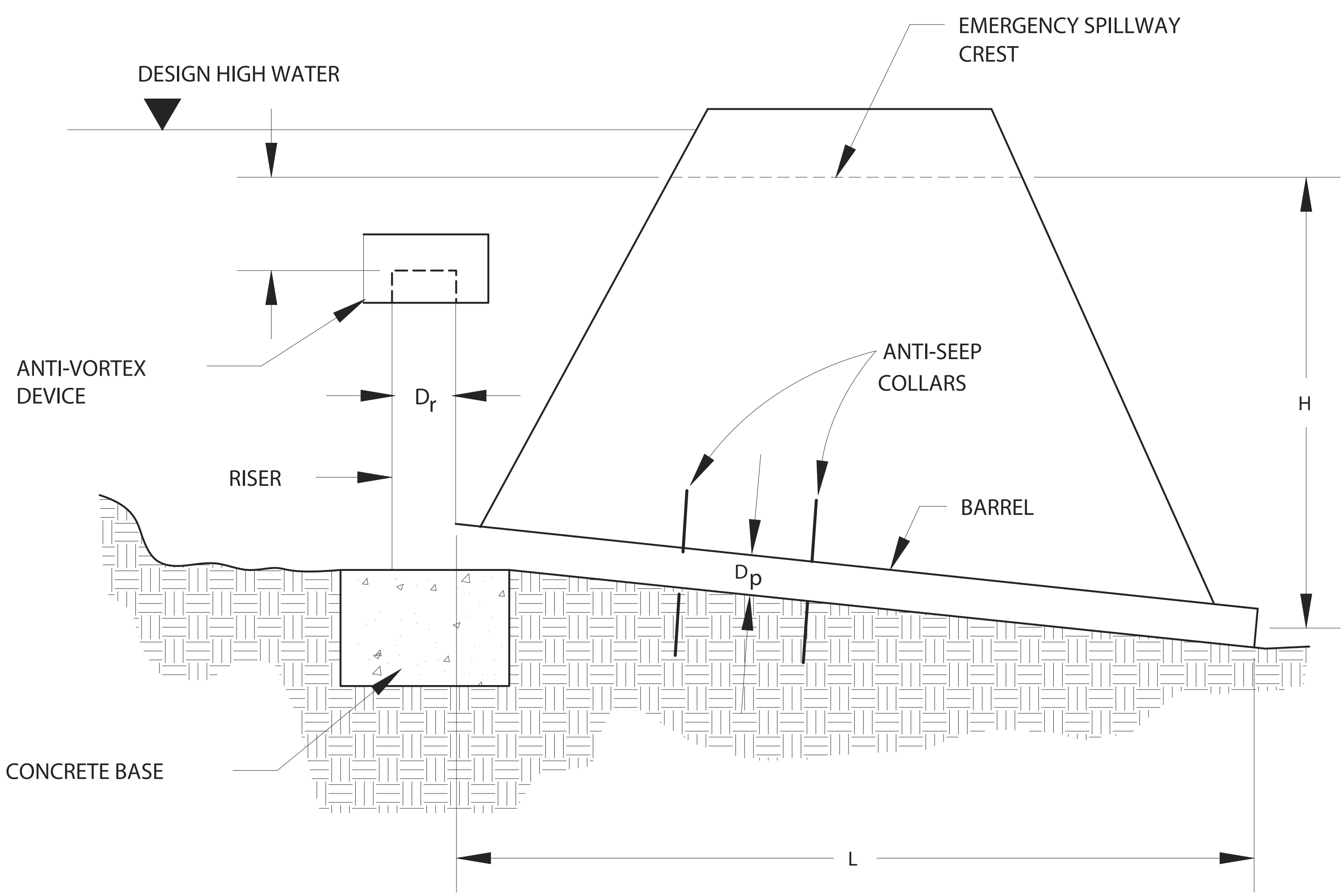


NOTE: WITH CONCRETE RISER, USE PVC SCHEDULE 40 STUB FOR DEWATERING ORIFICE

Source: VA DSWC

Figure 5

Principal Spillway Design



H = HEAD ON PIPE THROUGH EMBANKMENT

h = HEAD OVER RISER CREST

L = LENGTH OF PIPE THROUGH EMBANKMENT

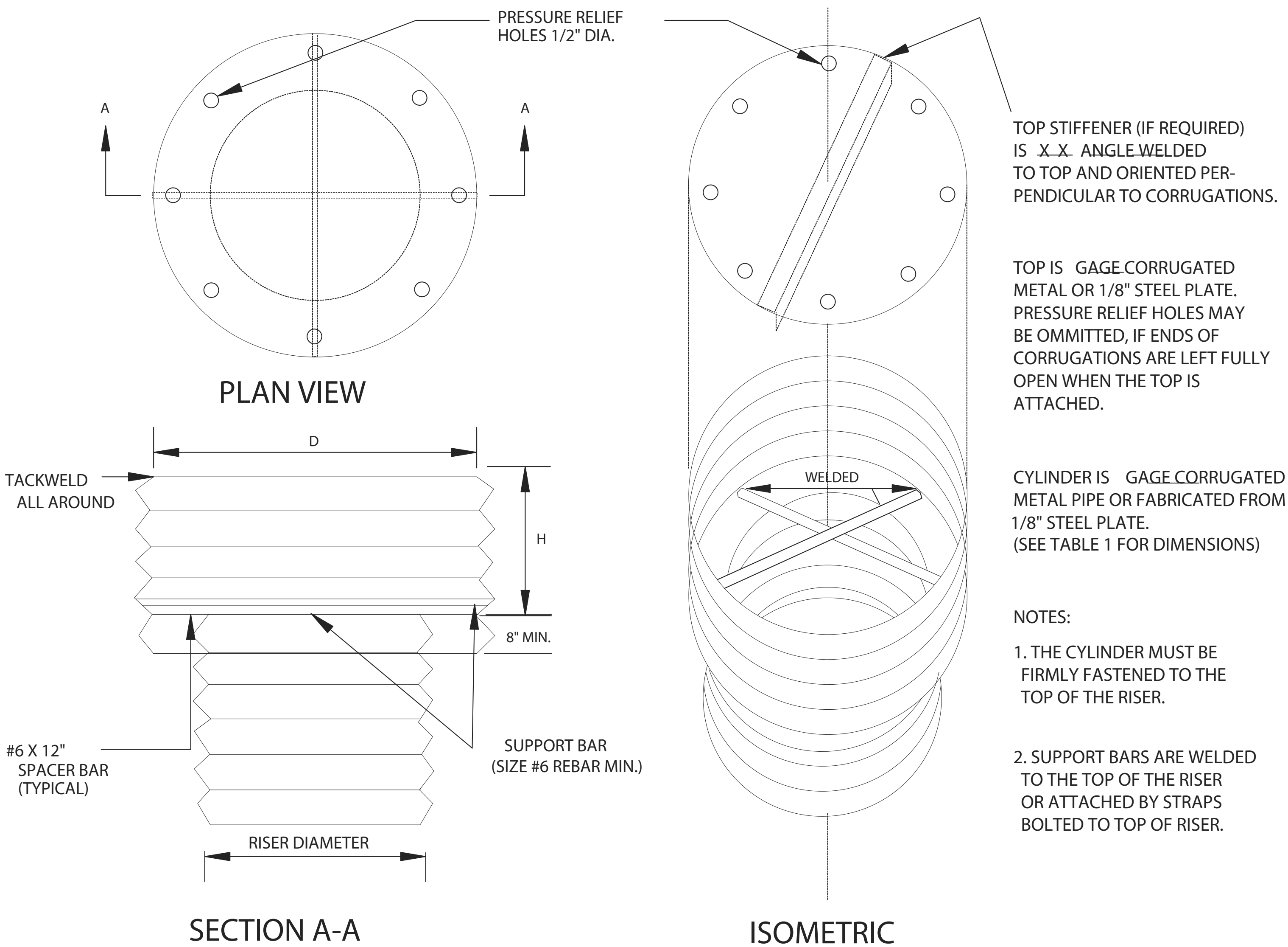
D_p = DIAMETER OF PIPE THROUGH EMBANKMENT

D_r = DIAMETER OF RISER

Source: VA DSWC

Figure 6

Anti - Vortex Device Design



Source: US - NRCS

Figure 7

Concentric Trash Rack and Anti-Vortex Device Design Table

Riser Diam., inches	Cylinder			Minimum Size Support Bar	Minimum Top	
	Diameter, inches	Thickness, gage	Height, inches		Thickness	Stiffener
12	18	16	6	#6 Rebar or 1 1/2" x 1 1/2" x 3/16" angle	16 ga. (F&C)	-
15	21	16	7	" "	" "	-
18	27	16	8	" "	" "	-
21	30	16	11	" "	16 ga.(C), 14 ga.(F)	-
24	36	16	13	" "	" "	-
27	42	16	15	" "	" "	-
36	54	14	17	#8 Rebar	14 ga.(C), 12 ga.(F)	-
42	60	14	19	" "	" "	-
48	72	14	21	1 1/4" pipe or 1 1/4" x 1 1/4" x 1/4" angle	14 ga.(C), 10 ga.(F)	-
54	78	14	25	" "	" "	-
60	90	14	29	1 1/2" pipe or 1 1/2" x 1 1/2" x 1/4" angle	12 ga.(C), 8 ga.(F)	-
66	96	14	33	2" pipe or 2" x 2" x 3/16" angle	12 ga.(C), 8 ga.(F) w/stiffener	2" x 2 1/4" angle
72	102	14	36	" "	" "	2 1/2" x 2 1/2" x 1/4" angle
78	114	14	39	2 1/2" pipe or 2" x 2" x 1/4" angle	" "	" "
84	120	12	42	2 1/2" pipe or 2 1/2" x 2 1/2" x 1/4" angle	" "	2 1/2" x 2 1/2" x 5/16" angle

Note: The table above is useful only for corrugated metal pipe. Concrete trash rack and anti-vortex devices are also available. Manufacturer’s recommendations should be followed for concrete applications.

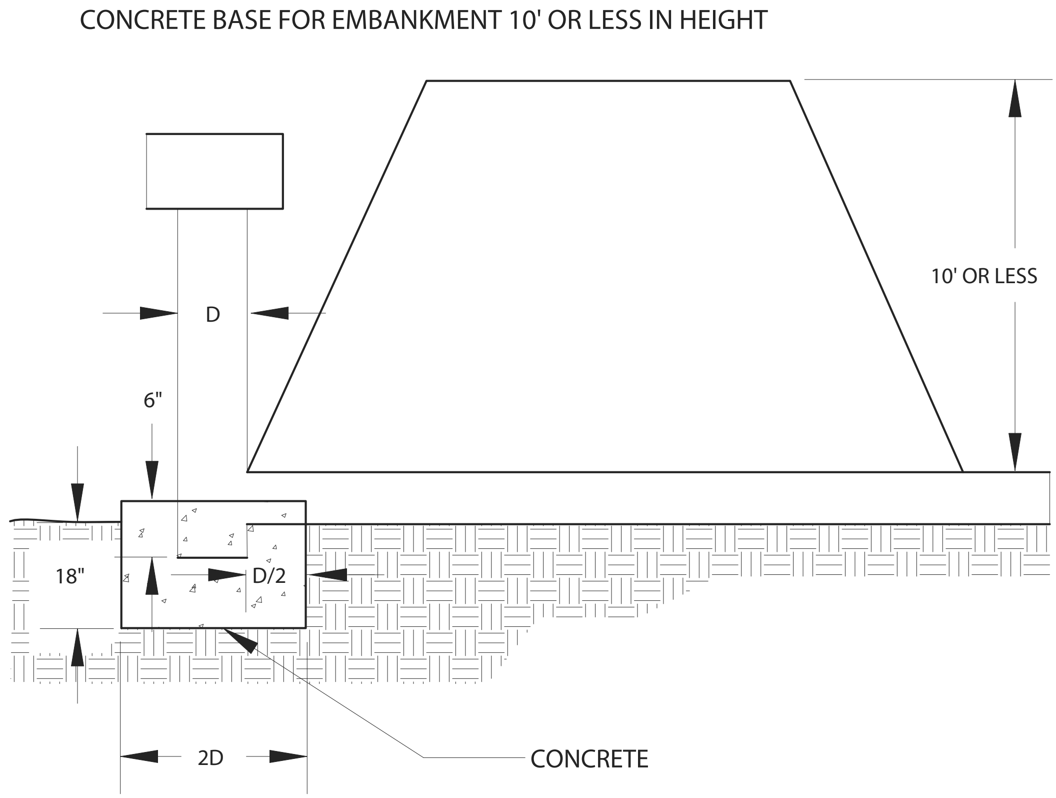
Note: Corrugation for 12”-36” pipe measures 2 2/3” x ½”; for 42”-84” the corrugation measures 5” x 1” or 8” x 1”.

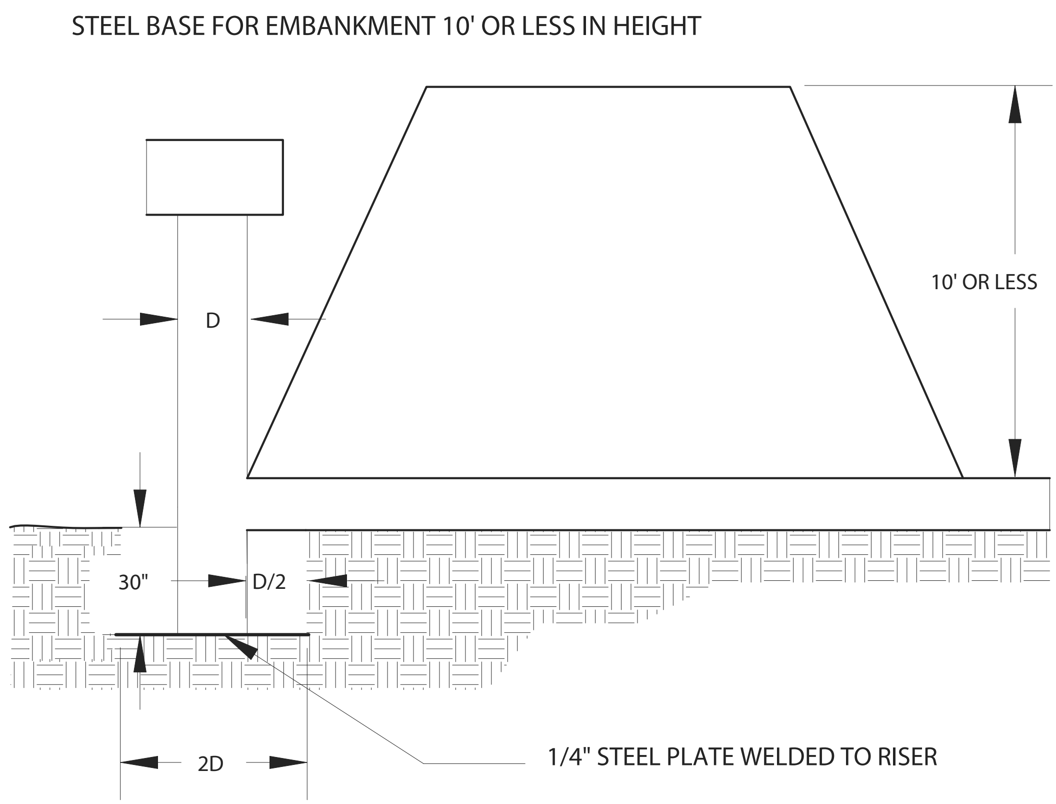
Note: C = corrugated; F = flat.

Source: VA DSWC

Table 1

Riser Pipe Base Conditions For Embankments Less Than 10' High





Source: VA DSWC

Figure 8

twice the diameter of the riser shall be welded to the riser pipe. It shall be covered with 2.5 feet of stone, gravel, or compacted soil to prevent flotation. See Figure 8 for details.

Note: If the steel base is used, special attention should be given to compaction so that 95% compaction is achieved over the plate. Also, added precautions should be taken to ensure that material over the plate is not removed accidentally during removal of sediment from basin. One method would be to use simple marker posts at the four corners.

Outlet Barrel: The drainpipe barrel of the principal spillway, which extends through the embankment, shall be designed to carry the flow provided by the riser of the principal spillway with the water level at the crest of the emergency spillway. The riser and all pipe connections shall be completely watertight and not have any other holes, leaks, gashes, or perforations other than designed openings. The minimum size of the pipe shall be 10 inches in diameter. The connection between the riser and the barrel must be watertight to prevent local scouring. The outlet of the barrel must be protected to prevent erosion or scour of downstream areas. Where discharge occurs at the property line, drainage easements will be obtained in accordance with local ordinances. Adequate notes and references regarding such easements will be shown on the erosion and sediment control plan. Measures may include excavated plunge pools, riprap, impact basins, revetments, or other effective methods. Refer to specification **Storm Drain Outlet Protection - OP**.

Caution should be given in directing all outlet water from the impoundment to a receiving watercourse so that natural flow paths are preserved above off-site property owners.

Anti-Seep Collars: Anti-seep collars are used to reduce uncontrolled seepage and prevent internal erosion or "piping" inside the dam along the drainpipe barrel. Anti-seep collars shall be used on the drainpipe barrel of the principal spillway within the normal saturation zone of the embankment to increase the seepage length by at least 10%, if either of the following two conditions is met:

1. The settled height of the embankment exceeds 10 feet.

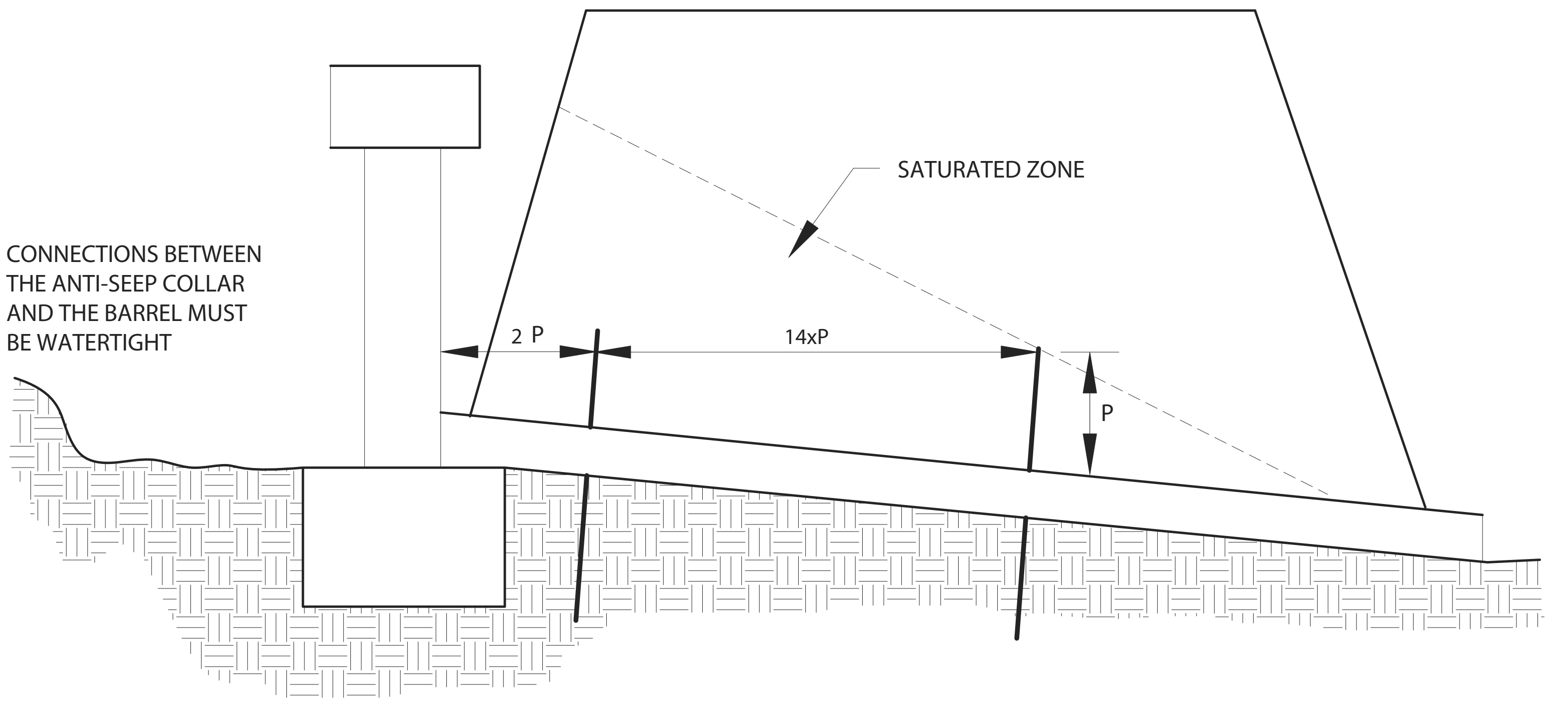
2. The embankment has a low silt-clay content (Unified Soil Classes SM or GM) and the barrel is greater than 10 inches in diameter.

The anti-seep collars shall be installed within the saturated zone. The maximum spacing between collars shall be 14 times the projection of the collars above the barrel. Collars shall not be closer than 2 feet to a pipe joint. Collars should be placed sufficiently far apart to allow space for hauling and compacting equipment. Precautions should be taken to ensure that 95% compaction is achieved around the collars. Connections between the collars and the barrel shall be watertight. See Figure 9 for details.

Emergency Spillway: The emergency spillway acts as a safety release for a sediment basin, or any impoundment type structure, by conveying the larger, less frequent storms through the basin without overtopping or damaging the embankment. The emergency spillway also acts as its name implies - an emergency outlet - in case emergency circumstances arise from excessive sedimentation or damage to the riser, which prevents flow through the principal spillway. The emergency spillway shall consist of an open channel constructed adjacent to the embankment over undisturbed material (not fill, such as the dam embankment). The emergency spillway shall be lined with a non-erodible material such as dumped and compacted riprap or engineered vegetation. Design of an emergency spillway requires the special expertise of a qualified, engineering design professional. The control section is a level portion of the spillway channel at the highest elevation in the channel. See Figure 10 for location of emergency spillway and Figure 11 for an example excavated earth spillway.

The designer must ensure that the spillway lining (either grassed or riprapped) would withstand the high velocities expected in the

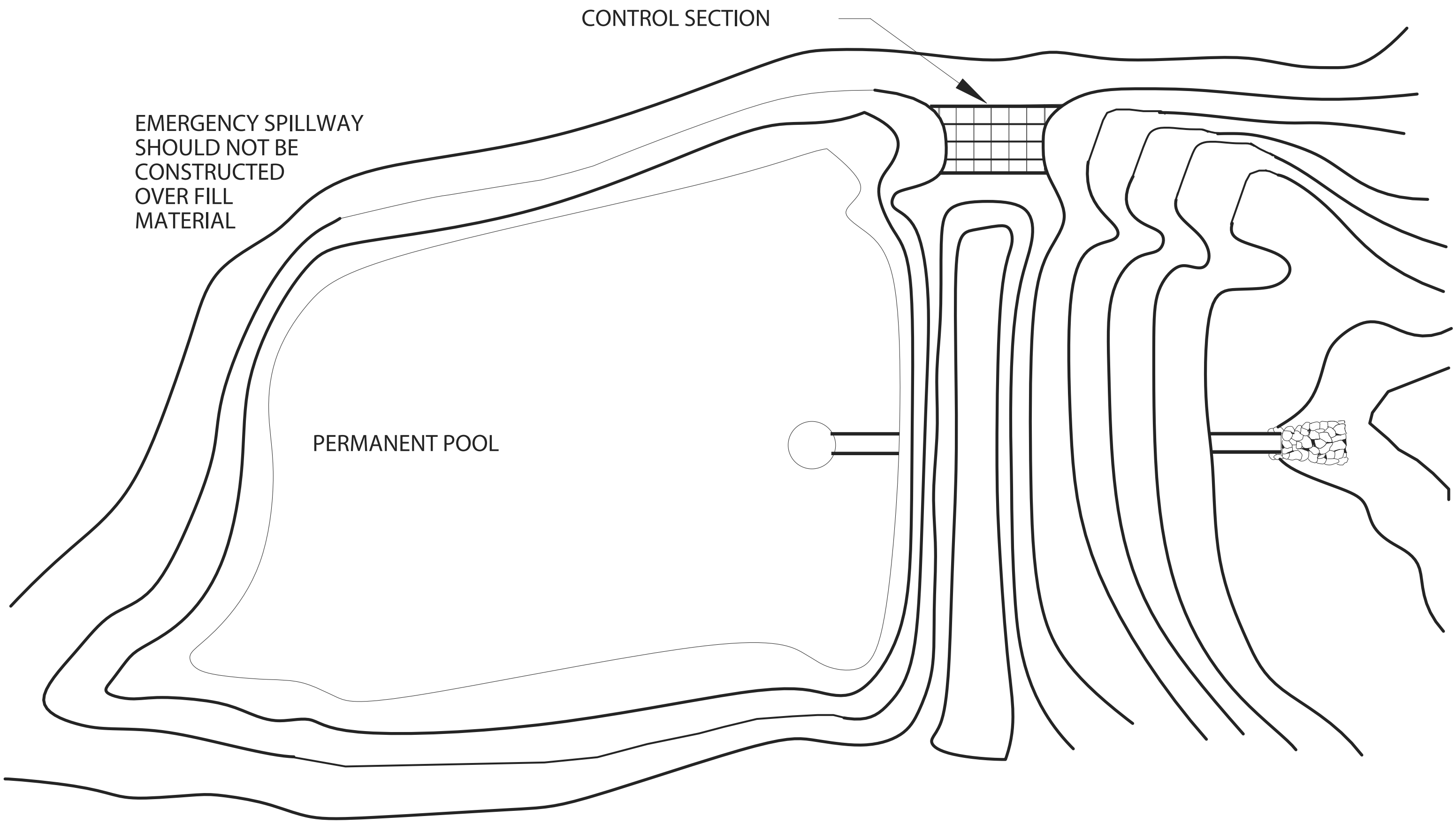
Anti-Seep Collar



Source: VA DSWC

Figure 9

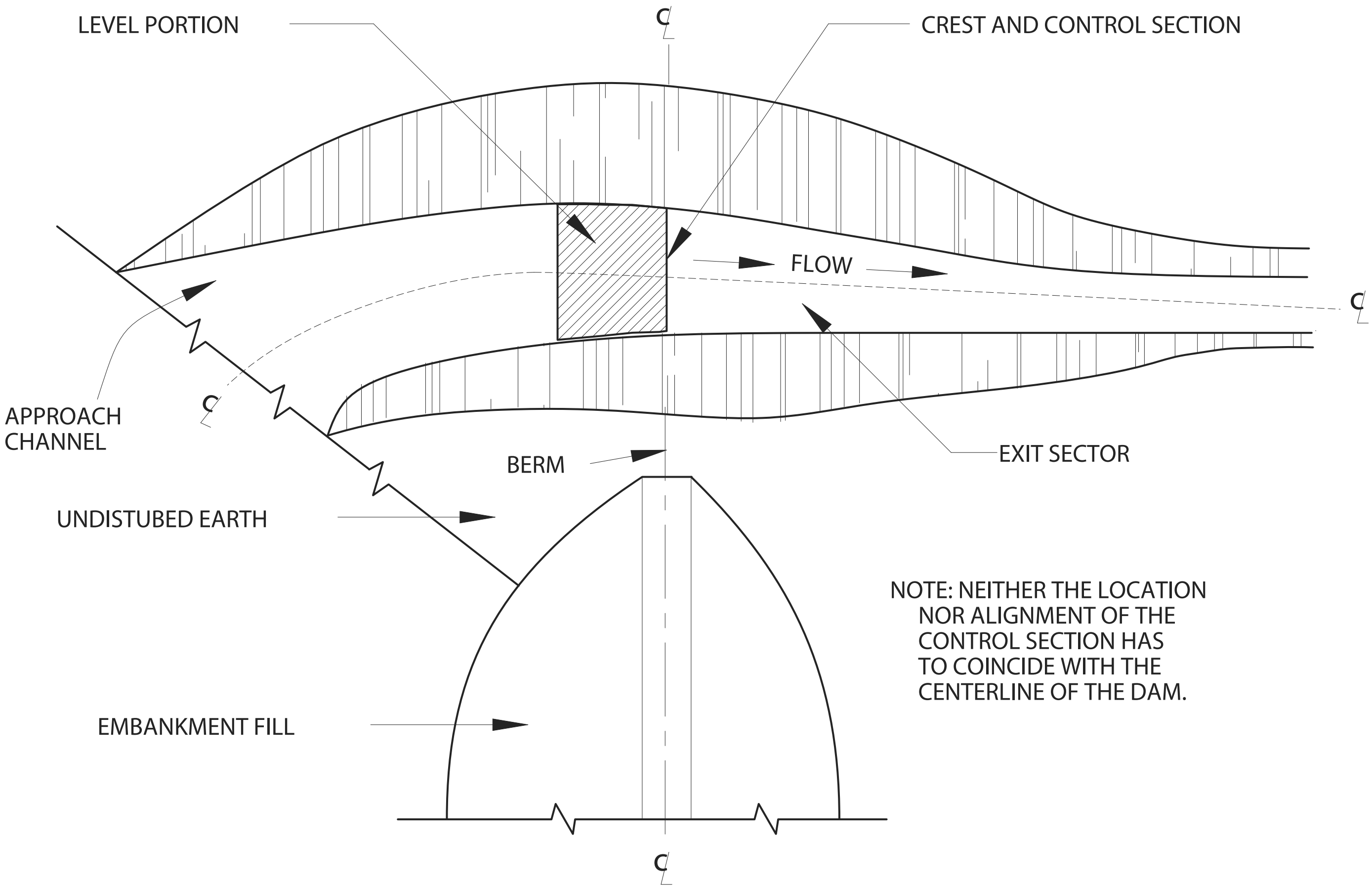
Emergency Spillway



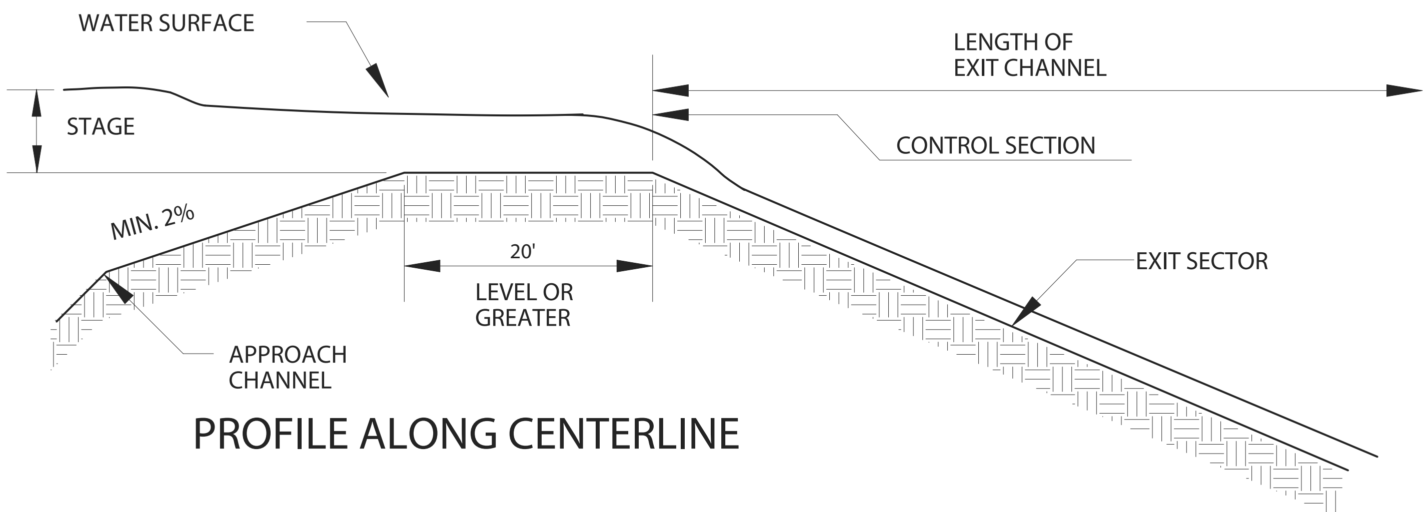
Source: VA DSWC

Figure 10

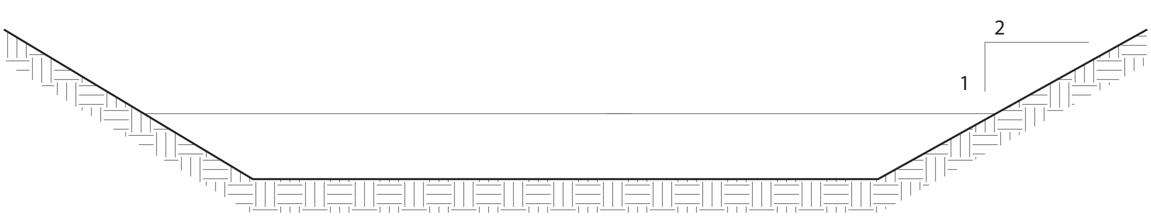
Excavated Earth Spillway



PLAN VIEW



PROFILE ALONG CENTERLINE



CROSS-SECTION AT CONTROL SECTION

Source: US - NRCS

Figure 11

spillway approach, crest and channel sections without causing erosion.

An evaluation of site and downstream conditions must be made to determine the feasibility and justification for the incorporation of an emergency spillway. In some cases, the site topography does not allow a spillway to be constructed in undisturbed material, and the temporary nature of the facility may not warrant the cost of disturbing more acreage to construct and armor a spillway. The principal spillway should then be sized to convey all the design storms. If the basin is designed as a permanent facility with downstream restrictions, the added expense of constructing and armoring an emergency spillway may be justified.

Capacity: The emergency spillway shall be designed to carry the portion of the peak runoff discharge expected from a 25-year 24-hour storm event that is not credited to the principal spillway.

Design Elevations: The maximum 25-year storm pool elevation shall have a freeboard of at least 1.0 foot below the top of the embankment. The control crest of the emergency spillway channel shall be at least 1.0 foot above the crest of the principal spillway.

Location: The emergency spillway channel should be located so that it is not constructed over erosion-susceptible fill material. The channel should be located so as to avoid sharp turns or bends. The channel should return the flow of water to a defined channel downstream from the embankment. Caution should be given in directing all outlet water from the impoundment to an established watercourse so that natural flow paths are preserved above off-site property owners.

Maximum Velocities: The maximum allowable velocity in the emergency spillway channel will depend upon the type of lining used. Vegetated linings should only be used for low velocity and non-scouring applications. Otherwise, non-erodible linings such as concrete or riprap should be used. For non-erodible linings, design velocities may be increased. However, the emergency spillway channel shall return the flow to the downstream receiving channel at a non-eroding velocity.

Stabilization: The embankment of the sediment basin shall receive vegetative cover immediately after installation. Refer to **Disturbed Area Stabilization (With Permanent Vegetation) - PS** for recommended vegetation details. If excavation is required in constructing the basin, side slopes should not be steeper than 1.5:1.

Disposal: Sediment should be removed from the basin before the sediment level reaches higher than 1 foot below the bottom of the dewatering orifice, or before one-half of the permanent pool volume has been filled in, whichever occurs first. Plans for the sediment basin should indicate the methods for disposing of sediment removed from the basin. Possible alternatives are to use the material in fill areas on-site, or removal to an approved off-site location.

Sediment basin plans should indicate the final disposition of the sediment basin after the upstream drainage area is stabilized. The plans should include methods for the removal of excess water lying over the sediment, stabilization of the basin site, and the disposal of any excess material. Where the sediment basin has been designed as a permanent storm water management basin, plans should also address the steps necessary for the conversion of the sediment basin into a permanent detention or retention structure.

Health and Safety: The designer and developer should be aware of the potential hazards that a temporary wet pond represents to the health and safety of a neighborhood. Sediment basins can be attractive to children and can be dangerous to those who may accidentally slip into the water and soft mud or who may become entrapped at flowing inlets. The basin area should, therefore, be fenced or otherwise made inaccessible to persons or animals, unless this is deemed unnecessary due to the remoteness of the site or other circumstances. Strategically placed signs around the impoundment reading "DANGER-QUICKSAND" should also be installed. In addition to signs and fences, consideration should be given to frequent inspection, regular maintenance and provision for security at such facilities. In any case, local ordinances and regulations regarding health and safety must be adhered to.

Flocculant and Coagulant Aids: In situations with particularly fine-grained and erodible soil (i.e. loess or clays), the design professional may consider the use of flocculants added to the sediment-laden runoff prior to its entrance into the sediment basin. These flocculants encourage the fine sediment particles to "stick together" which allows them to settle more quickly and effectively. Coagulant aids such as polymers may be used. A common polymer for this purpose is synthetic polyacrylamide (PAM), which may be added to the sediment-laden runoff as it enters the basin, or sprayed on bare slopes to reduce erosion and the transport of sediment. Refer to specification **Polyacrylamide - PAM**. The means of delivery for these chemicals and their application rates will be provided by the engineer in the form of appropriate standard detail drawings and specifications. An example of such an application is shown in Figure 12.

CONSTRUCTION SPECIFICATIONS

Site Preparation: Areas under the proposed embankment (or any structural works related to the sediment basin) shall first be cleared, grubbed, and stripped of topsoil. All trees, vegetation, roots, and/or other objectionable or inappropriate materials should be removed and disposed of by appropriate methods. In order to facilitate clean out and restoration, the pool area, as measured from the top of the principal spillway, should be cleared of all brush and trees.

Cut-Off Trench: For earth-fill embankments, a cutoff trench shall be excavated along the centerline of the earth fill embankment (dam). The trench must extend at least 1 foot into a stable, impervious layer of soil and have a minimum depth of 2 feet. The cutoff trench shall extend up both abutments to the riser crest elevation. The minimum width shall be 4 feet, but also must be wide enough to permit operation of compaction equipment. The side slopes shall be no steeper than 1:1. Compaction requirements shall be the same as those for the embankment. The trench shall be drained during the backfilling/compacting operations.

Embankment: The fill material shall be taken from approved borrow areas (shown on the plans). It shall be clean mineral soil, free of roots, woody vegetation, stumps, sod, oversized stones, rocks, or other perishable or objectionable material. The fill material selected must have enough strength for the dam to remain stable and be tight enough, when properly compacted, to prevent excessive percolation of water through the dam. Fill containing particles ranging from small gravel or coarse sand to fine sand and clay in desired proportion is appropriate. Any embankment material should contain approximately 20% clay particles by weight. Using the Unified Soil Classification System, SC (Clayey sand), GC (clayey gravel) and CL ("low liquid limit" clay) are among the preferred types of embankment soils. Areas on which fill is to be placed shall be scarified prior to placement of fill. The fill material should contain the proper amount of moisture to ensure that at least 95% compaction will be achieved. Fill material will be placed in 6-inch continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment, or by using a compactor. Special care shall be taken in compacting around the anti-seep collars (compact by hand, if necessary) to avoid damage and achieve desired compaction. The embankment shall be constructed to an elevation 10% higher than the design height to allow for settlement if compaction is obtained with hauling equipment. If compactors are used for compaction, the overbuild may be reduced to not less than 5%.

Addition of Chemical Flocculent at Sediment Basin Entrance

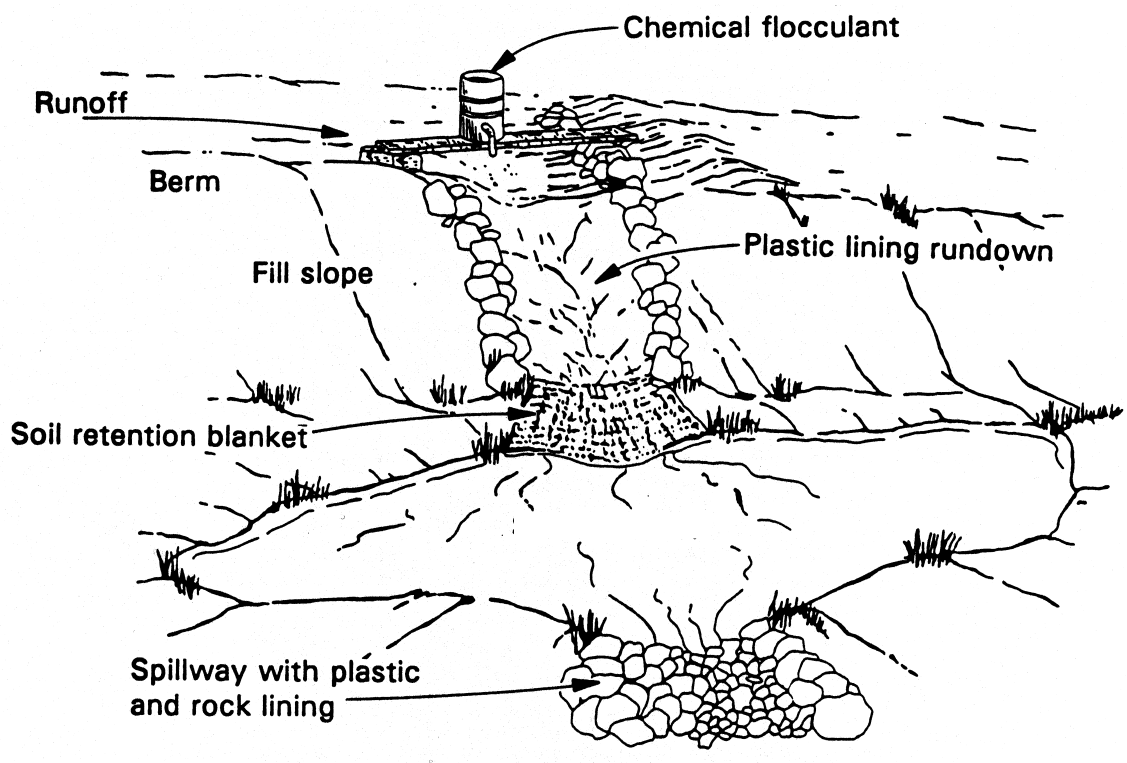


Figure 12

Note: Illustration shows exaggerated foreshortening. Sediment Basin length to width proportions are incorrect and not according to specifications within this standard.

Principal Spillway: The riser of the principal spillway shall be securely attached to the barrel pipe by welding the full circumference making a watertight connection. The barrel and riser shall be placed on a firmly compacted soil foundation. The base of the riser shall be firmly anchored according to design criteria to prevent its floating. Pervious materials such as sand, gravel, or crushed stone shall not be used as backfill around the barrel or anti-seep collars. Fill material shall be placed around the pipe in 4-inch layers and compacted until 95% compaction is achieved (compact by hand, if necessary). A minimum of two feet of fill shall be hand-compacted over the barrel before crossing it with construction equipment.

Emergency Spillway: The emergency spillway shall be installed in undisturbed ground. The implementation of planned elevations, grades, design width, entrance and exit channel slopes are critical to the successful operation of the emergency spillway and must be constructed within a tolerance of 0.2 feet. If the emergency spillway requires erosion protection other than vegetation, the lining shall not compromise the capacity of the emergency spillway, e.g. the emergency spillway shall be over-excavated so that the lining will be flush with the designed slope surface.

Vegetative Stabilization: The embankment and emergency spillway of the sediment basin shall be stabilized with the appropriate temporary or permanent vegetation immediately after construction of the basin. Trees and/or shrubs should not be allowed to grow upon the embankment due to the ability for the roots of such vegetation to destabilize the embankment and/or encourage piping.

Erosion and Sediment Control: The construction of the sediment basin shall be carried out in a manner such that it does not result in sediment problems downstream.

Safety: All state and local requirements shall be met concerning fencing and signs warning the public of the hazards of soft, saturated sediment and flood water.

Final Disposal: When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposits are to be leveled or otherwise disposed of in accordance with the SWPPP. The proposed use of a sediment basin site will often dictate final disposition of the basin and any sediment contained therein. If the site is scheduled for future construction, then the embankment and trapped sediment must be removed, safely disposed of, and backfilled with a structural fill. When the basin area is to remain open space, the pond may be pumped dry, graded and backfilled.

INSPECTION

Inspections of sediment basins should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. The basin embankment should be checked according to permit requirements to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The emergency spillway should be checked to ensure that its lining is well established and erosion-resistant.

MAINTENANCE

Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified. Accumulated sediment shall be removed from the basin when it reaches the specified distance below the top of the riser. Sediment shall not enter adjacent streams or drainage ways during sediment removal or disposal. The sediment shall not be deposited downstream from the embankment, adjacent to a stream or floodplain.

A recommended inspection and maintenance checklist is shown on the following page.

Sample Field Inspection and Maintenance Checklist

Name/location of site: ___________________________
Date: _____________
Inspector(s): ____________________________
____

- Inspect embankment slopes and crest for :
  - erosion ____
  - structural stability (slumping, bulging, sliding) __________________________
  - cracking (both longitudinal and lateral) _______________________________
  - wet or soft spots or on lower downstream slope and toe area _____________
  - discolored or muddy water seepage _________________________________
  - uneven crest settlement (check if adequate freeboard above
  - emergency crest) ____
- Inspect basin slopes for:
  - erosion____
  - sliding or slumping ____
- Check amount of sediment in pond for cleaning ____________________________________
- Check baffles for structural soundness and holes or breaks ___________________________
- Inspect trash rack and anti-vortex device for debris and blockage ______________________
- Inspect emergency spillway for obstructions ____
- Check emergency spillway entrance, channelway, and exit for significant erosion and scouring ____
- Check principal spillway outlet for excessive scouring and erosion _____________________
- Check all safety- and health-related facilities (warning signs, fences, etc.)________________
- Check for vandalism, especially around and inside principal spillway riser _______________
- Inspect dewatering device for debris/silt clogging and structural integrity _________________
  - Inspect outside edge of outlet pipe for excessive seepage (i.e., flowing water) -- look for discolored or muddy water along the sides as a sign of serious piping or pipe joint separation.

____

Other comments and observations:
____
____
____
____
____
____

Sediment Trap - $\boxed{\text{ST}}$

DEFINITION

A temporary ponding area formed by constructing an earthen embankment with a stone outlet.

PURPOSE

To detain sediment-laden runoff from small, disturbed areas long enough to allow the majority of the sediment to settle out.

CONDITIONS

Sediment traps should be used below disturbed areas where the total contributing drainage area is **less than 10 acres**. If the contributing drainage area is **10 acres or greater**, refer to **Sediment Basin - SB**. The maximum useful life of the sediment trap should be no longer than 18 months.

Sediment traps, along with other controls intended to retain sediment, should be constructed as a first step in any land disturbing activity and should be made functional before upslope land disturbance takes place. The sediment trap may be constructed either independently or in conjunction with a diversion. Refer to specification **Diversion - DI**.

Sediment should be periodically removed from the trap to maintain the required volume. The SWPPP should detail how excavated sediment is to be disposed of, such as by use in fill areas on site or removal to an approved off-site location.

DESIGN CRITERIA

Professionals familiar with the design of storm water basins should prepare construction plans and drawings. The trap should be designed using sound engineering practice.

Trap Capacity: The sediment trap should have an initial storage volume of 3618 cubic feet or 134 cubic yards per acre of drainage area, half of which should be in the form of a permanent pool or wet storage to provide a stable settling medium. The remaining half should be in the form of a draw down or dry storage that will provide extended settling time during less frequent, larger storm events. Excavation may be required to attain the necessary storage volume. The volume of the wet storage should be measured from the low point of the excavated area to the base of the outlet structure. (See Figure 1) The volume of the dry storage should be measured from the base of the outlet to the crest of the outlet (overflow mechanism). Sediment should be removed from the basin when the volume of the wet storage is reduced by one-half.

For a sediment trap, the wet storage volume may be approximated as follows:

$$V_1 = 0.85 \times A_l \times D_l$$

where,

V_l = the wet storage volume in cubic feet

A_l = the surface area of the flooded area at the base of the outlet in square feet

D_l = the maximum depth in feet, measured from the low point in the trap to the base of the outlet

The dry storage volume may be approximated by the average end method as follows:

$$V_2 = [(A_1 + A_2)/2] \text{ X } D_2$$

where,

V_2 = the dry storage volume in cubic feet.

A_l - the surface area of the flooded area at the base of the outlet in square feet

A_2 - the surface area of the flooded area at the crest of the outlet (overflow mechanism), in square feet

D_2 - the depth in feet, measured from the base of the outlet to the crest of the outlet

The designer should seek to provide a storage area that has a minimum 2:1 length to width ratio (measured from point of maximum runoff introduction to outlet).

Note: There are 27 cubic feet per cubic yard. Conversion between cubic feet and cubic yards is as follows:

number of cubic feet x 0.037 = number of cubic yards

or

number of cubic feet / 27= number of cubic yards

Excavation: Side slopes of excavated areas should be no steeper than 1:1. The maximum depth of excavation within the wet storage area should be 4 feet to facilitate clean-out.

Embankment Cross-Section: The maximum height of the sediment trap embankment should be 5 feet as measured from the base of the stone outlet. Minimum top widths (W) and outlet heights (Ho) for various embankment heights (H) are shown in Figure 2. Side slopes of the embankment should be 2:1 or less.

Outlet: The outlet for the sediment trap should consist of a stone section of the embankment located at the low point in the basin. A combination of coarse aggregate and riprap should be used to provide for filtering/detention as well as outlet stability. The smaller stone should be TDOT #3, #357, or #5 Coarse Aggregate (smaller stone sizes will enhance filter efficiency) and riprap should be "Class A-1". See specification **Riprap – RR** for aggregate size tables.

Geotextile should be placed beneath the stone outlet, separating it from the subsoil surface. The geotextile should be placed immediately adjacent to the subgrade without any voids and extend five feet beyond the down stream toe of the outlet to prevent scour. Refer to specification **Geotextile – GE**.

The minimum length of the outlet should be 6 feet times the number of acres comprising the total area draining to the trap. See Figure 1 for further illustration. The crest of the stone outlet must be **at least 1.0 foot below the top of the embankment** to ensure that the flow will travel over the stone and not the embankment.

Removal: Sediment traps must be removed after the contributing drainage area is stabilized. The SWPPP should show how the site of the sediment trap is to be graded and stabilized after removal.

CONSTRUCTION SPECIFICATIONS

1. The area under the embankment should be cleared, grubbed, and stripped of any vegetation and root mat.

2. Fill material for the embankment should be free of roots or other woody vegetation, organic material, large stones, and other objectionable material. The embankment should be compacted in 6-inch layers by traversing with construction equipment.

3. All cut and fill slopes should be 2:1 or less (except for excavated, wet storage area which may be at a maximum 1:1. grade).

4. Construction operations should be carried out in such a manner that erosion during construction of the structure is minimized.

5. The earthen embankment should be seeded with temporary or permanent seeding immediately after installation. Refer to specification **Disturbed Area Stabilization (With Temporary Vegetation) - TS** and/or **(With Permanent Vegetation) – PS**.

6. The structure should be removed and the area stabilized when the upslope drainage area has been stabilized.

INSPECTIONS

Inspections of temporary sediment traps should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspections may be conducted only once per month.

The structure should be checked regularly to ensure that it is structurally sound and has not been damaged by erosion or construction equipment. The height of the stone outlet should be checked to ensure that its center is at least 1 foot below the top of the embankment.

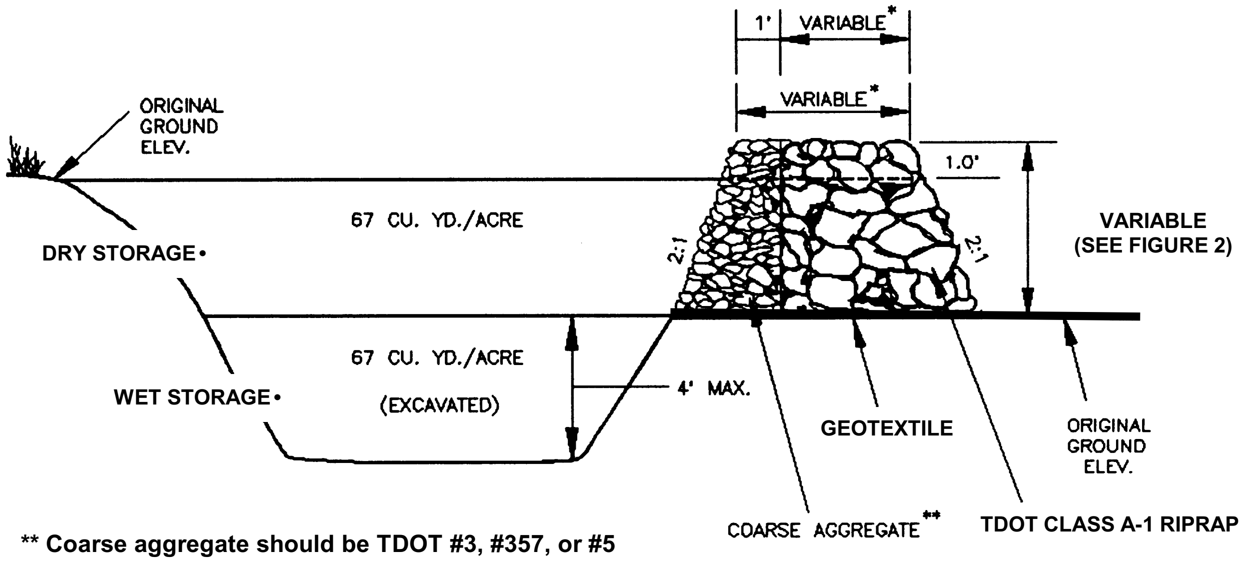
Filter stone should be checked to ensure that filtration performance is maintained. Stone choked with sediment should be removed and cleaned or replaced.

MAINTENANCE

Sediment should be removed and the trap restored to its original dimensions when the sediment has accumulated to one half the design volume of the wet storage. Sediment removal from the basin should be deposited in a suitable area and in such a manner that it will not erode and cause sedimentation problems.

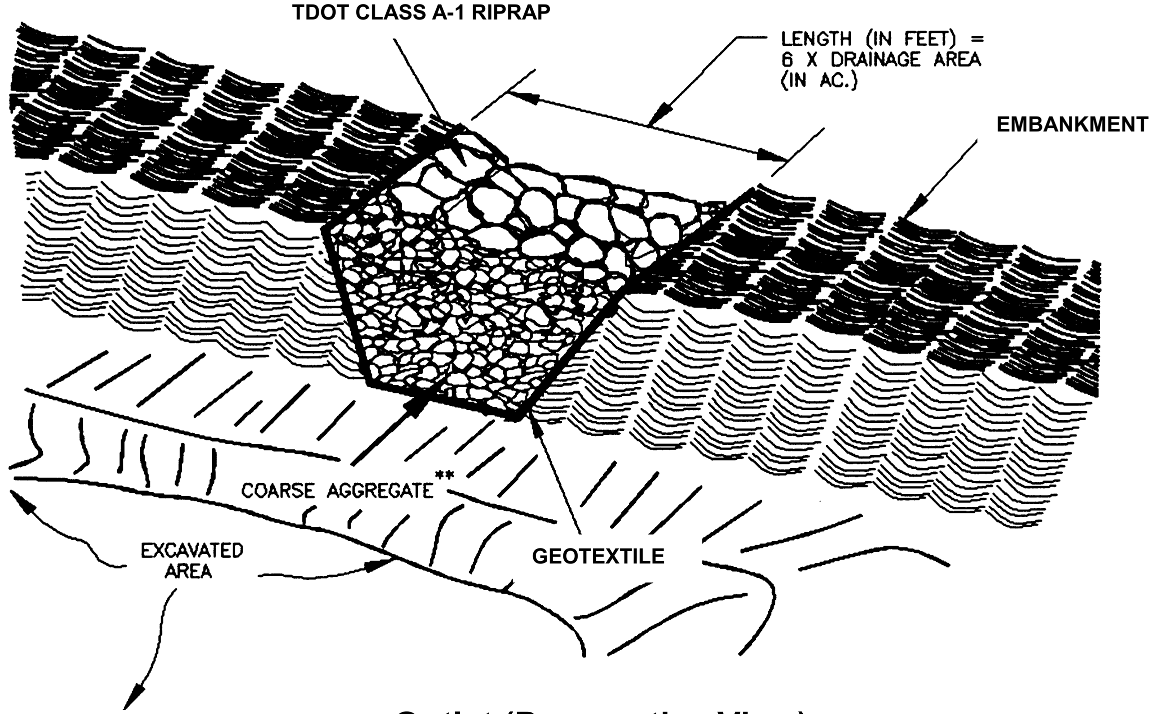
Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Sediment Trap



** Coarse aggregate should be TDOT #3, #357, or #5

Cross Section of Outlet

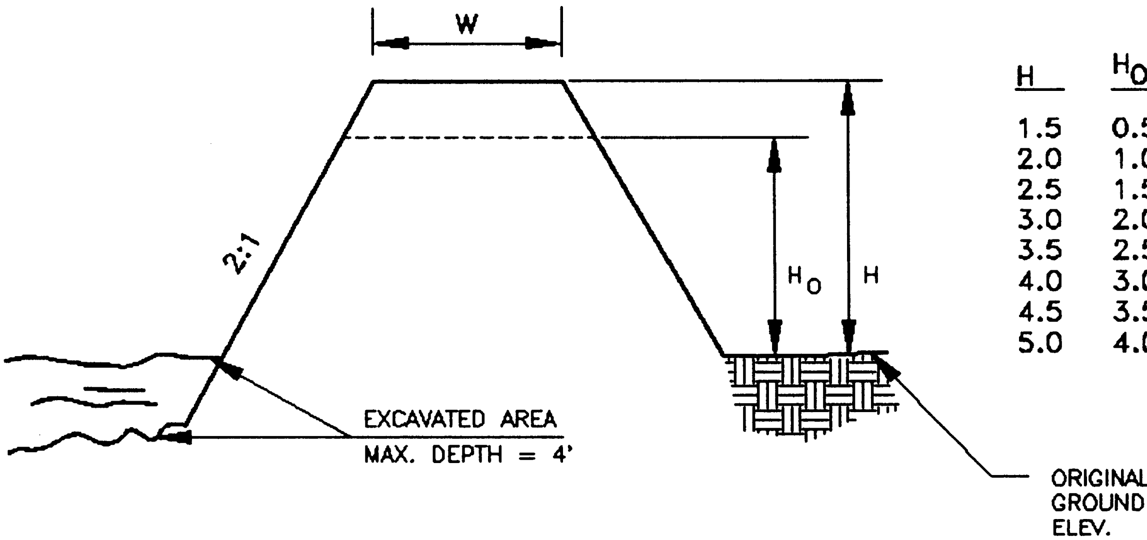


Outlet (Perspective View)

Figure 1

Source: VA DSWC

Minimum Top Width (W) Required for Sediment Trap Embankments According to Height of Embankment (Feet)



H	H_O	W
1.5	0.5	2.0
2.0	1.0	2.0
2.5	1.5	2.5
3.0	2.0	2.5
3.5	2.5	3.0
4.0	3.0	3.0
4.5	3.5	4.0
5.0	4.0	4.5

Figure 2

Source: VA DSWC

Silt Fence - SF

DEFINITION

A silt fence is a temporary sediment barrier made of woven, synthetic filtration fabric supported by steel or wood posts.

PURPOSE

The purpose of a silt fence is to prevent sediment carried by sheet flow from leaving the site and entering natural drainage ways or storm drainage systems by slowing storm water runoff and causing the deposition of sediment at the structure. Silt fencing encourages sheet flow and reduces the potential for development of rills and gullies.

CONDITIONS

Silt fence should be installed where sheet flow runoff can be stored behind the barrier without damaging the barrier or the submerged area behind the barrier.

Silt fence should not be installed across streams, ditches, waterways, or other concentrated flow areas.

DESIGN CRITERIA

All silt fence should be installed along the contour, never up or down a slope.

Where all sheet flow runoff is to be stored behind the fence (where no storm water disposal system is present), maximum slope length behind a silt fence should not exceed those shown in Table 1. **The drainage area should not exceed l/4 acre for every 100 feet of silt fence.**

Criteria for Silt Fence Placement

Land Slope (percent)	Maximum Slope Length Above Fence (feet)
<2	100
2 to 5	75
5 to 10	50
10 to 20	25
>20*	15
* In areas where the slope is greater than 20 %, a flat area length of 10 feet between the toe of the slope and the fence should be provided	

Table 1

Source: GA SWCC

Type A Silt Fence - SF-A: This 36-inch wide filter fabric should be used on developments where the life of the project is six months or greater. See Figure 1.

Type B Silt Fence - SF-B: Though only 22-inches wide, this filter fabric allows the same flow rate as Type A silt fence. Type B silt fence should be limited to use on minor projects, such as residential home sites or small commercial developments where permanent stabilization will be achieved in less than six months. See Figure 2.

Type C Silt Fence - SF-C: Type C fence is 36-inches wide with wire reinforcement. The wire reinforcement is necessary because this fabric allows almost three times the flow rate as Type A silt fence. Type C silt fence should be used where runoff flows or velocities are particularly high or where slopes exceed a vertical height of 10 feet. See Figure 3.

Along stream buffers and other sensitive areas, two rows of Type C silt fence may be used.

Table 2 contains specific information concerning specification requirements for all three types of material.

CONSTRUCTION SPECIFICATIONS

Silt fence should be placed on the contour. On slopes with grades greater than 7%, the silt fence should be located at least 5 to 7 feet beyond the base. Turn the ends of the silt fence upslope so that a certain depth of storm water may be retained in front of the silt fence. The impounded depth should be at least 12 inches, but no more than the height of the silt fence. Hay or straw bales should be staked in place at the end of the row of silt fence as an emergency overflow. This will allow detained water, exceeding the capacity of the silt fence, to be filtered and released quickly (see Figure 4). **The bottom edge of silt fence must be entrenched and backfilled to be effective.**

The silt fence should be purchased in a continuous roll cut to the length of the barrier to avoid the use of joints. When joints are unavoidable, filter cloth should be spliced together only at a supporting post, with a minimum 6-inch overlap, and securely sealed. See Figure 5 for splicing requirements.

Post installation should start at the center of the low-point (if applicable) with remaining posts spaced 6 feet apart for Type A and B silt fences and 4 feet apart for Type C silt fence. While Type A and B silt fences can be used with both wood and steel posts, only steel posts should be used with Type C silt fence due to the flow capacity of the fabric. See Table 3, for post size and fasteners requirements. See Figure 6 for fastener placement.

INSPECTION

Inspect silt fence before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspections may be conducted only once per month.

MAINTENANCE

Sediment should be removed once it has accumulated to one-half the original height of the barrier. Filter fabric should be replaced whenever it has deteriorated to such an extent that the effectiveness of the fabric is reduced (approximately six months). Silt fence should remain in place until disturbed areas have been permanently stabilized. All sediment accumulated at the fence should be removed and properly disposed of before the fence is removed.

Silt Fence Specifications

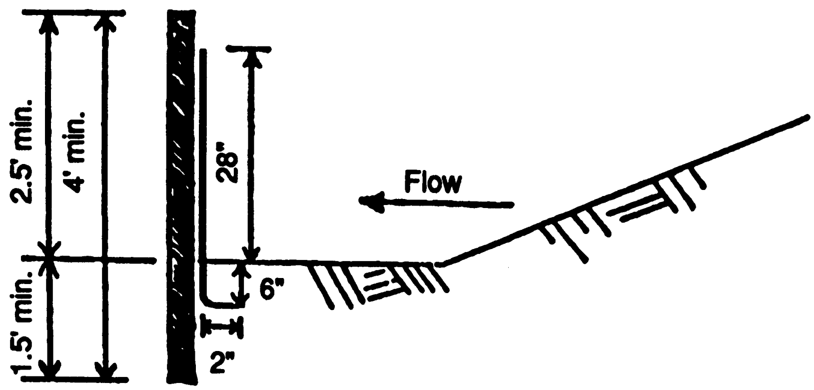
TYPE FENCE	A	B	C
Tensile Strength (Lbs. Min.) (1) (ASTM D-4632)	Warp - 120 Fill - 100	Warp - 120 Fill - 100	Warp - 260 Fill - 180
Elongation (% Max.) (ASTM D-4632)	40	40	40
AOS (Apparent Opening Size) (Max. Sieve Size) (ASTM D-4751)	#30	#30	#30
Flow Rate (Gal/Min/Sq. Ft.) (GDT-87)	25	25	70
Ultraviolet Stability (2) (ASTM D-4632 after 300 hours weathering in accordance with ASTM D-4355)	80	80	80
Bursting Strength (PSI Min.) (ASTM D-3786 Diaphragm Bursting Strength Tester)	175	175	175
Minimum Fabric Width (Inches)	36	22	36

(1) Minimum roll average of five specimens.
(2) Percent of required initial minimum tensile strength.

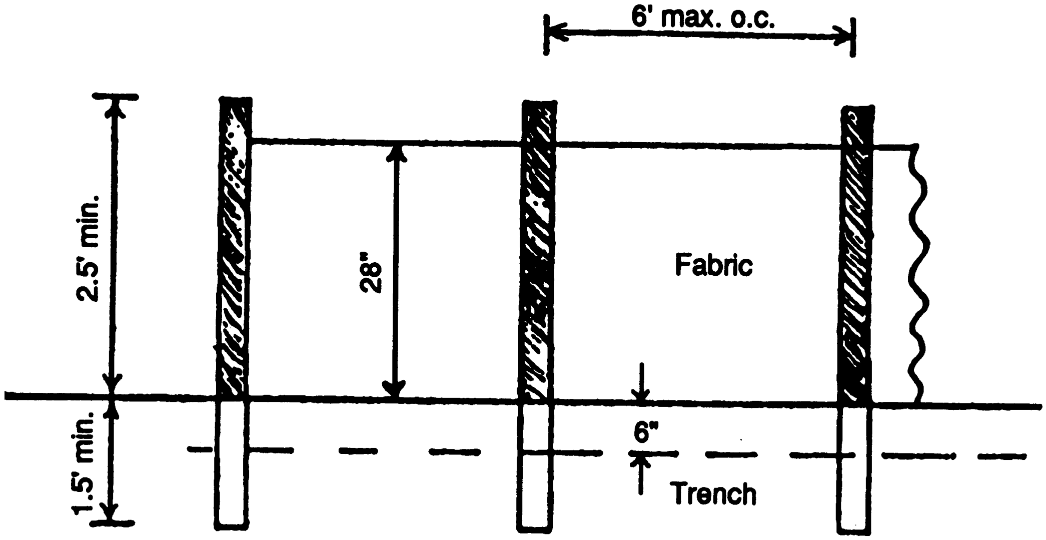
Table 2

Source: GA SWCC

Silt Fence – Type A



SIDE VIEW



FRONT VIEW

Figure 1

Source: GA SWCC

Silt Fence – Type B

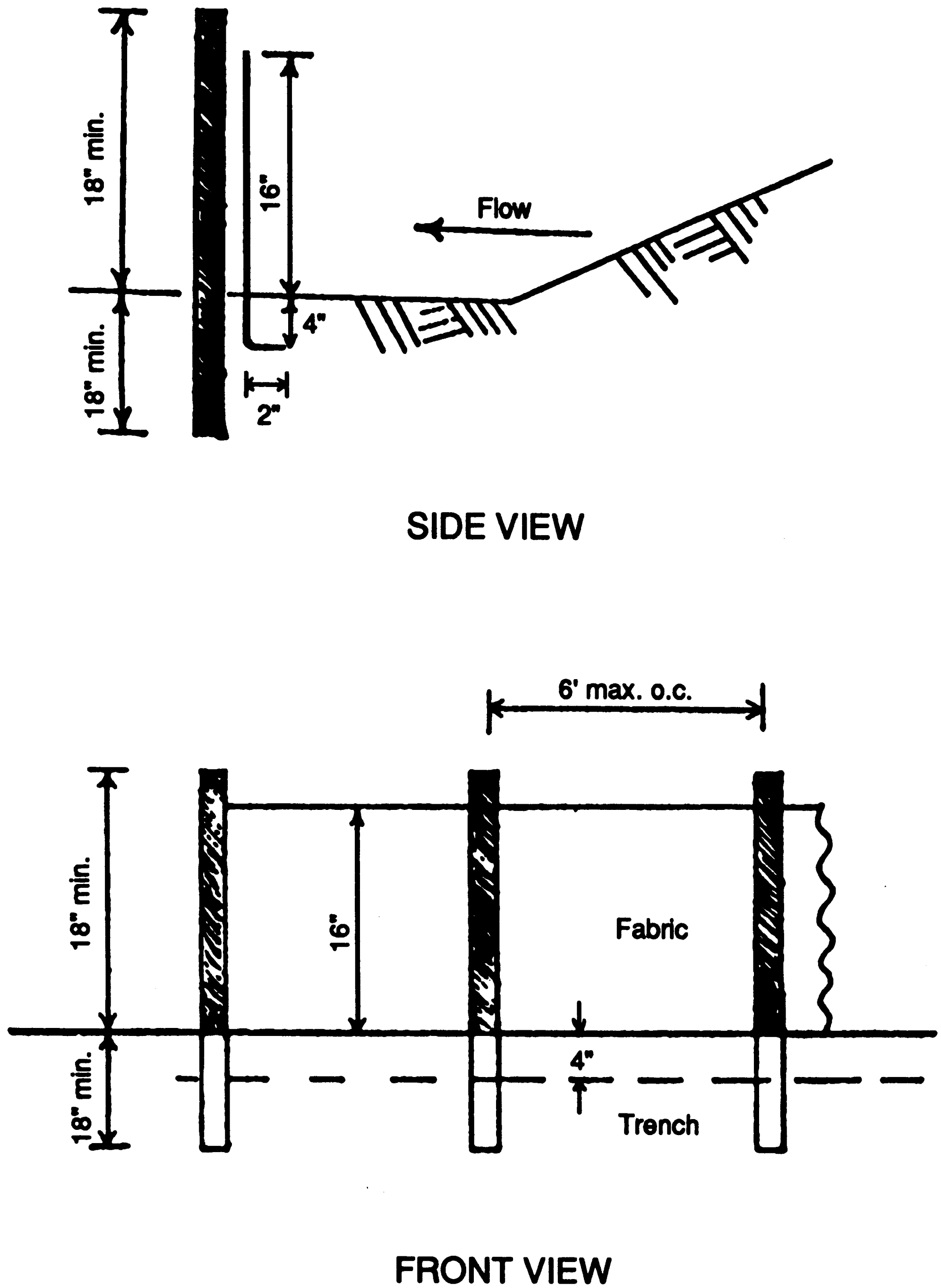
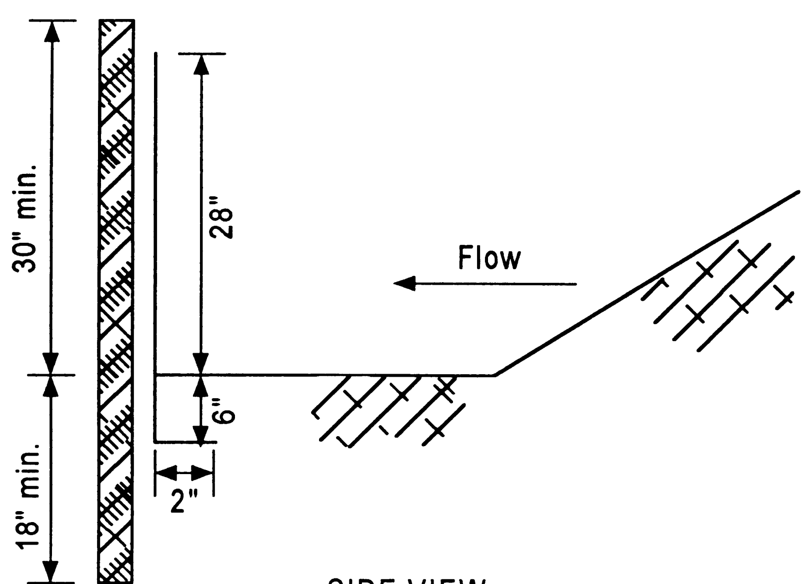


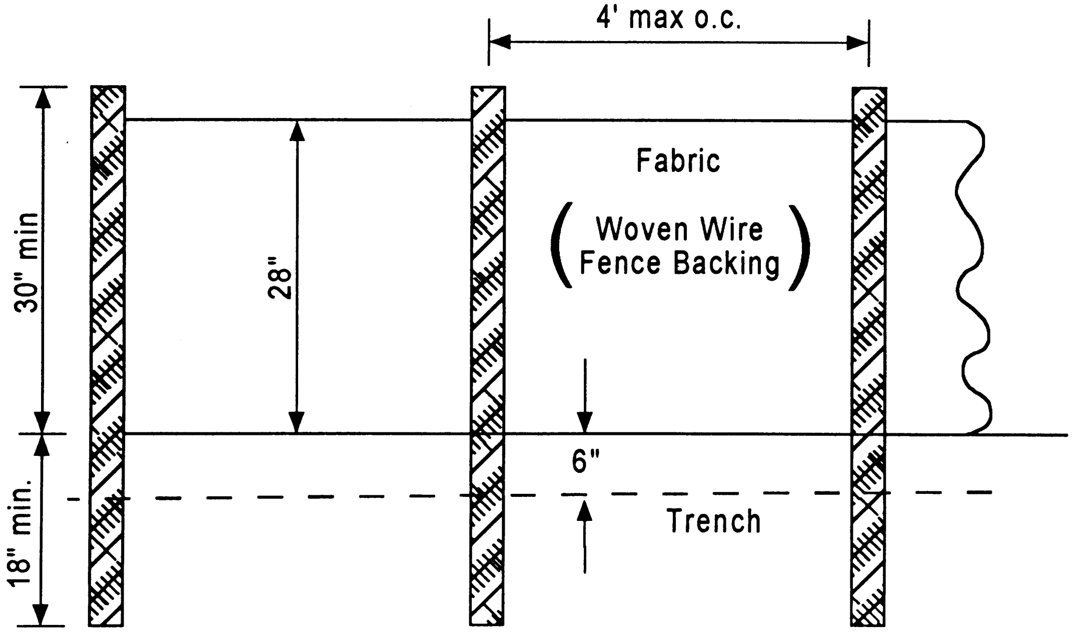
Figure 2

Source: GA SWCC

Silt Fence – Type C



SIDE VIEW



FRONT VIEW

Figure 3

Source: GA SWCC

Silt Fence Below a Steep or Long Grade

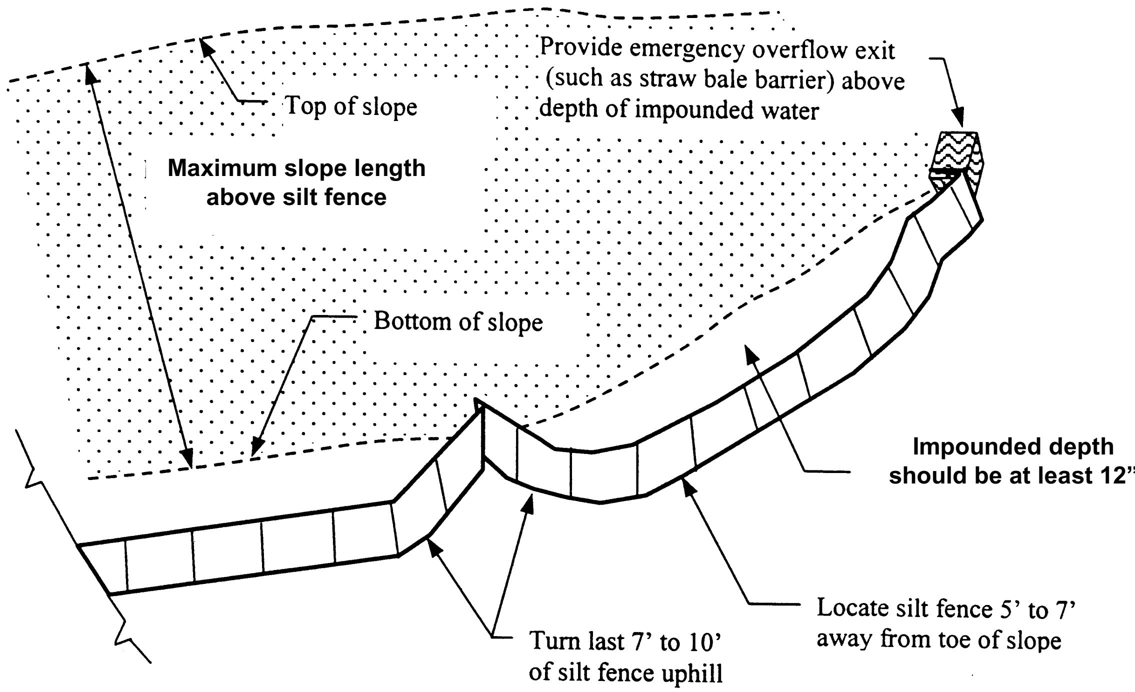


Figure 4

Source: Knoxville Engineering Department

Joining Silt Fence Sections

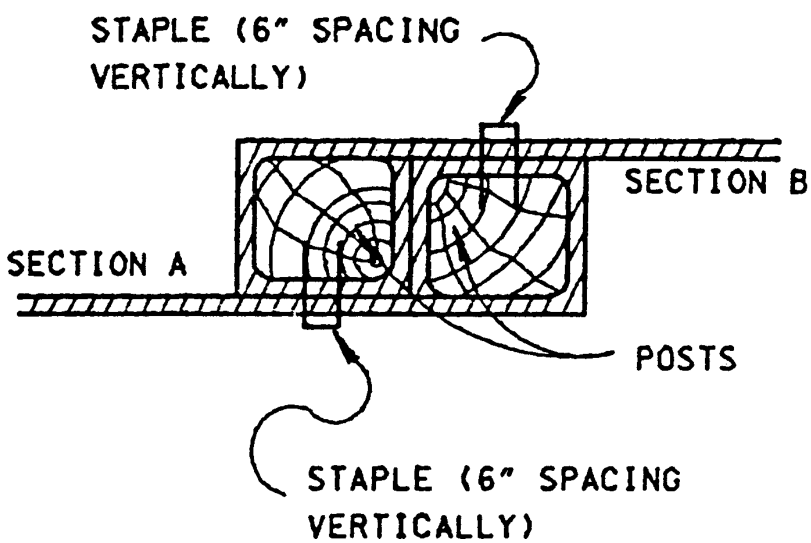


Figure 5

Source: TDOT English Standard Drawings

Post Size and Fastener Requirements

POST SIZE

	Minimum Length	Type of Post	Size of Post
Type A	4'	Soft wood	3" dia. or 2x4
		Oak	1.5" x 1.5"
		Steel	1.3lb./ft. min.
Type B	3'	Soft wood	2" dia. or 2x2
		Oak	1" x 1"
		Steel	.75lb./ft. min.
Type C	4'	Steel	1.3lb./ft. min.

FASTENERS FOR WOOD POSTS

	Gauge	Crown	Legs	Staples/Post
Wire Staples	17 min.	3/4" wide	1/2" long	5 min.

	Gauge	Length	Button Heads	Nail/Post
Nails	14 min.	1"	3/4"	4 min.

Note: Filter fabric may also be attached to the post by wire, cord, and pockets.

Table 3

Source: GA SWCC

Fastener Placement

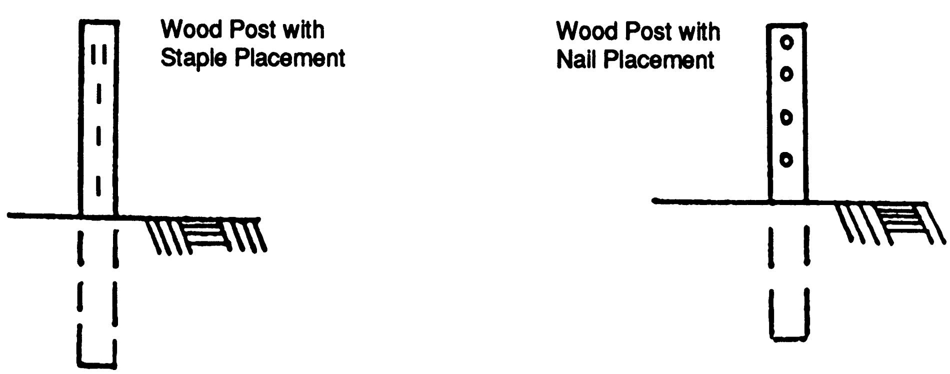
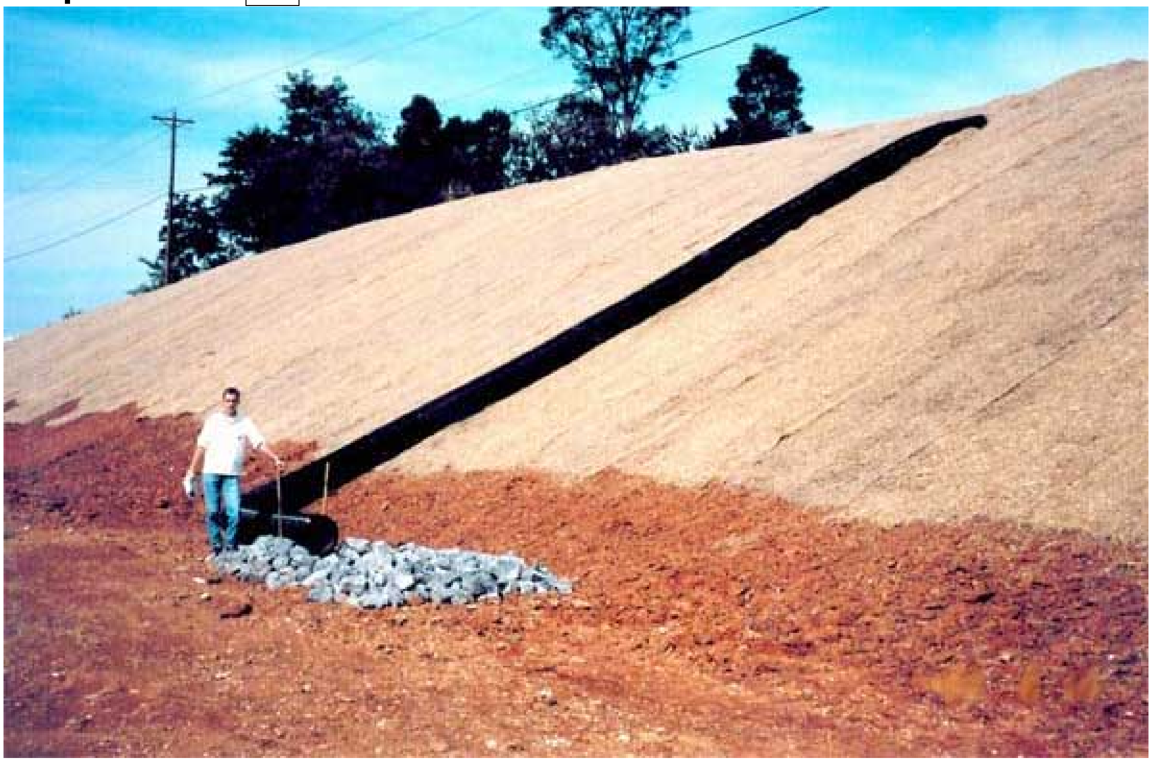


Figure 6

Source: GA SWCC

Slope Drain - $\boxed{SD}$



DEFINITION

A temporary pipe installed from top to bottom of a cut or fill slope.

PURPOSE

To convey storm water runoff down the face of a cut or fill slope without causing erosion on or below the slope.

CONDITIONS

Temporary slope drains are used where sheet or concentrated storm water flow could cause erosion as it moves down the face of a slope. These structures are removed once the permanent storm water disposal system is installed.

DESIGN CRITERIA

Formal design is not required. The following standards should be used:

Placement: The temporary slope drain should be located on undisturbed soil or well-compacted fill.

Diameter: The diameter of the temporary slope drain should provide sufficient capacity required to convey the maximum runoff expected during the life of the drain. Refer to Table 1 for selecting the pipe diameter of a slope drain.

Slope Drain Pipe Specifications

Maximum Drainage Area Per Pipe (acre)	Pipe Diameter (inches)
0.3	10
0.5	12
1	18

Table 1
Source: GA SWCC

Slope Drain Inlet and Outlet: See Figure 1 for typical slope drain details. Diversion structures are used to route runoff to the slope drain's "Tee" or "Ell" inlet at the top of the slope. The entrance section should slope toward the entrance to the slope drain at a minimum of 1/2–inch per foot. Thoroughly compact selected soil around the inlet section to prevent the pipe from being washed out by seepage or piping. A stone filter ring or other inlet protection may be placed at the inlet for added sediment filtering capacity. Refer to the specifications **Filter Ring - FR or Storm Drain Inlet Protection - IP.** These sediment-filtering devices should be removed if flooding or bank over wash occurs.

Rock riprap should be placed at the outlet for energy dissipation. A Tee outlet, flared end section, or other suitable device may be used in conjunction with the riprap for additional protection. Refer to **Storm Drain Outlet Protection - OP**.

Pipe Material: Design the slope drain using heavy-duty, flexible materials such as non-perforated, corrugated plastic pipe or specially designed flexible tubing. Use reinforced, hold-down grommets or stakes to anchor the pipe at intervals not to exceed 10 feet with the outlet end securely fastened in place. The pipe must extend beyond the toe of the slope.

CONSTRUCTION SPECIFICATIONS

A common failure of slope drains is caused by water saturating the soil at the inlet section and seeping along the pipe. This creates voids and piping to occur, causing washouts. Proper back filling around and under the pipe with stable soil material, and hand compacting in 6-inch lifts to achieve firm contact between the pipe and the soil at all points, will eliminate this type of failure.

1. Place slope drains on undisturbed soil or well-compacted fill.

2. The entrance section should slope toward the inlet to the slope drain at a minimum of 1/2–inch per foot.

3. Hand compact the soil under and around the inlet and exit sections in lifts not to exceed 6 inches.

4. Ensure that the fill used to anchor the slope drain inlet at the top of the slope has minimum dimensions of 1.5 ft. depth, 4 ft. top width, and 3:l side slopes.

5. Ensure that all slope drain connections are watertight.

6. Ensure that all fill material is well compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.

7. Place the drain slightly diagonally across the slope, extending the drain beyond the toe of the slope. Curve the outlet uphill and adequately protect the outlet from erosion.

8. If the drain is conveying sediment-laden runoff, direct all flows into a sediment trap or sediment basin.

9. Make the settled, compacted diversion no less than one foot above the top of the pipe at every point.

10. Immediately stabilize all disturbed areas following construction.

INSPECTION

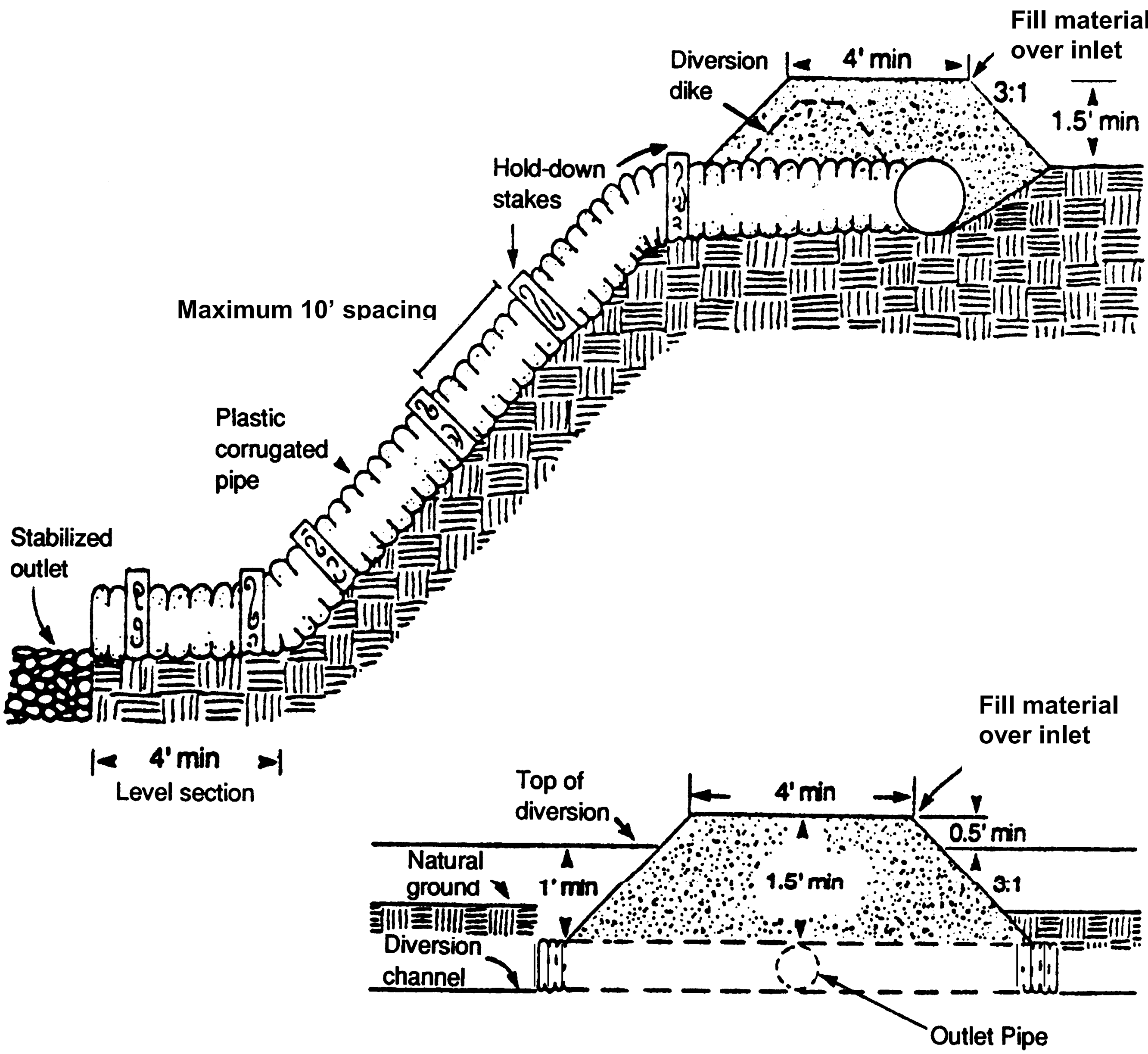
Inspections of the slope drain and supporting diversion should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days.

MAINTENANCE

Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

When the protected area has been permanently stabilized and the permanent storm water disposal system is fully functional, temporary measures may be removed, materials disposed of properly, and all disturbed areas stabilized appropriately. Refer to specifications **Disturbed Area Stabilization (With Permanent Vegetation and with Sod) - PS** and **SO**, respectively, and **Matting and Blankets - MA**.

Slope Drain Pipe and Inlet Detail



INLET DETAIL

Make all pipe connections watertight and secure so that the joints will not separate in use.

Figure 1

Source: GA SWCC

Storm Drain Inlet Protection - $\boxed{\text{IP}}$

DEFINITION

A temporary protective device formed around a storm drain drop inlet to trap sediment.

PURPOSE

To prevent sediment from entering storm drainage systems, prior to temporary or permanent stabilization of the disturbed area.

CONDITIONS

Storm drain inlet protection should be installed at or around all storm drain drop inlets that receive runoff from disturbed areas.

DESIGN CRITERIA

Many sediment-filtering devices can be designed to serve as storm drain inlet protection. Inlet protection must be self-draining unless otherwise protected in a fashion that will not present a safety hazard. **The drainage area served by the inlet protection should be no greater than one-half acre.** Runoff from larger drainage areas should be routed to a Sediment Trap or Sediment Basin. Refer to specifications for **Sediment Trap – ST** or **Sediment Basin – SB**.

If runoff may bypass the protected inlet, a berm should be constructed on the down slope side of the structure to prevent undercutting and erosion under the structure. Refer to **Diversion – DI**. Also, a stone filter ring may be used on the up slope side of the inlet to slow runoff and filter larger soil particles. Refer to **Filter Ring – FR.**

CONSTRUCTION SPECIFICATIONS

Inlet protection may be constructed on natural ground surface, on an excavated surface, or on machine compacted fill.

Silt Fence Inlet Protection IP-SF: This method of inlet protection is applicable where the inlet drains a relatively flat area (slope no greater than 5%) and should not apply to inlets receiving concentrated flows, such as in street or highway medians. As shown in Figure I, Type C silt fence supported by 2x4-inch wood or equivalent steel posts, with a minimum length of three feet, should be used. The stakes should be spaced evenly around the perimeter of the inlet a maximum of 3 feet apart, and securely driven into the ground, approximately 18 inches deep.

The silt fence should be entrenched 12 inches and backfilled with crushed stone or compacted soil. Silt fence and wire should be securely fastened to the posts, and silt fence ends must be overlapped a minimum of 18 inches or wrapped together around a post to provide a continuous barrier around the inlet. Refer to **Silt Fence – SF** for installation requirements. Sediment should be removed when the sediment has accumulated to one-half the height of the inlet protection.

Baffle Box Inlet Protection IP-BB: This method is applicable for inlets receiving runoff with a higher volume or velocity. As shown in Figure 2, the baffle box should be constructed of 2” x 4” or 4” x 4” boards spaced a maximum of 1 inch apart or of plywood with weep holes 2 inches in diameter. The weep holes should be placed approximately 6 inches on center vertically and horizontally. The entire box is wrapped in Type C filter fabric that should be entrenched 12 inches and backfilled. Refer to **Silt Fence – SF** for installation requirements.

Clean coarse aggregate should be placed outside the box, all around the inlet, to a depth of 2 to 4 inches. Coarse aggregate should be TDOT #3, #357, or #5. If the aggregate filter becomes clogged with sediment so that it no longer adequately performs its function, the aggregate should be pulled away from the structure, cleaned, and replaced. Sediment should be removed when the sediment has accumulated to one-half the height of the inlet protection.

Block and Gravel Inlet Protection IP-BG: This method of inlet protection is applicable where heavy flows are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure. As shown in Figure 3, one block is placed on each side of the structure on its side in the bottom row to allow pool drainage. The foundation should be excavated at least 2 inches below the crest of the storm drain. The bottom rows of blocks are placed against the edge of the storm drain for lateral support and to avoid washouts when overflow occurs. If needed, lateral support may be given to subsequent rows by placing 2” x 4” wood studs through block openings.

Hardware cloth or comparable wire mesh with l/2 inch openings should be fitted over all block openings to hold gravel in place. Clean coarse aggregate should be placed up to 2 inches below the top block on a 2:l slope or flatter and smoothed to an even grade. Coarse aggregate should be TDOT #3, #357, or #5. If the aggregate filter becomes clogged with sediment so that it no longer adequately performs its function, the aggregate should be pulled away from the structure, cleaned, and replaced. Sediment should be removed when the sediment has accumulated to one-half the height of the inlet protection.

Gravel Inlet Protection IP-G: This method of inlet protection is applicable where heavy concentrated flows are expected. As shown in Figure 4, wire mesh should be laid over the drop inlet grate so that the wire extends a minimum of one foot beyond each side of the inlet structure. Wire mesh with ½ inch openings should be used. Clean coarse aggregate should be placed over the entire inlet structure, to a total depth of at least 12 inches. The aggregate should extend beyond the inlet structure at least 18 inches on all sides. Coarse aggregate should be TDOT #3, #357, or #5.

Sediment should be removed when the sediment has accumulated to one-half the height of the inlet protection. If the aggregate filter becomes clogged with sediment so that it no longer adequately performs its function, the aggregate should be pulled away from the structure, cleaned, and replaced.

Sod Inlet Protection IP-S: This method of inlet protection is applicable only at the time of permanent seeding, to protect the inlet from sediment and mulch material until permanent seeding has become established. As shown in Figure 5, the sod should be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure. Sod strips should be staggered so that adjacent strip ends are not aligned. Refer to **Disturbed Area Stabilization (With Sod) – SO** for soil preparation, and sod installation and maintenance.

INSPECTIONS

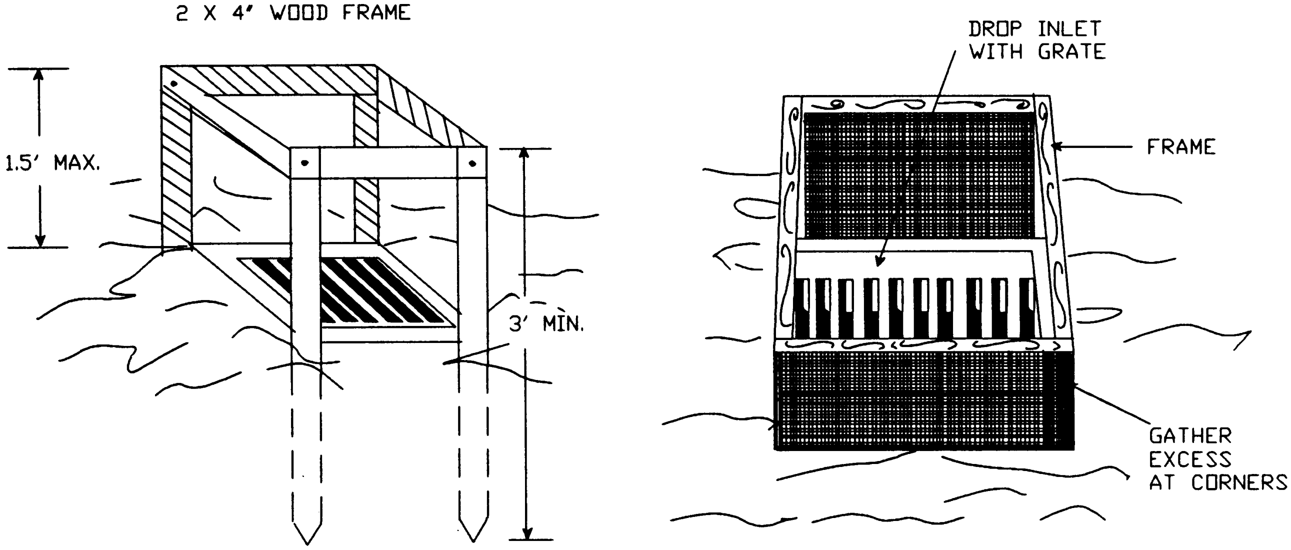
Inspections of storm drain inlet protection methods should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Where sites have been finally or temporarily stabilized, such inspection may be conducted only once per month.

MAINTENANCE

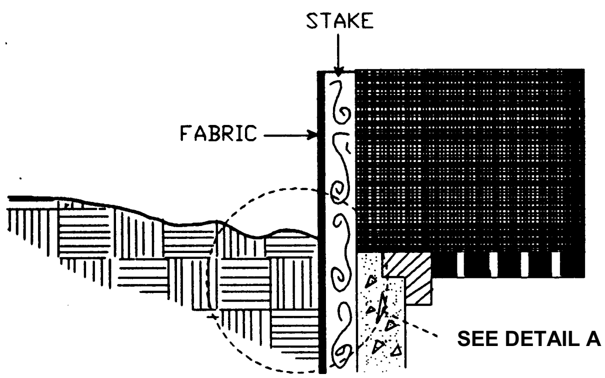
Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Sediment should not be allowed to wash into the storm drain inlet. It should be removed from the inlet protection and disposed of and stabilized so that it will not enter the inlet again. When the contributing drainage area has been permanently stabilized, all materials and any sediment should be removed, and either salvaged or disposed of properly. The disturbed area should be brought to proper grade, then smoothed and compacted. Appropriately stabilize all disturbed areas around the inlet.

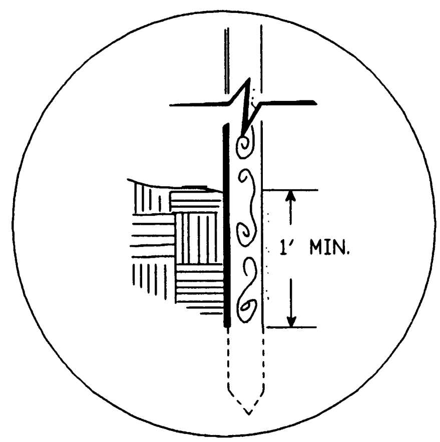
Silt Fence Inlet Protection – IP-SF



Perspective Views



Elevation of Stake and Silt Fence Orientation

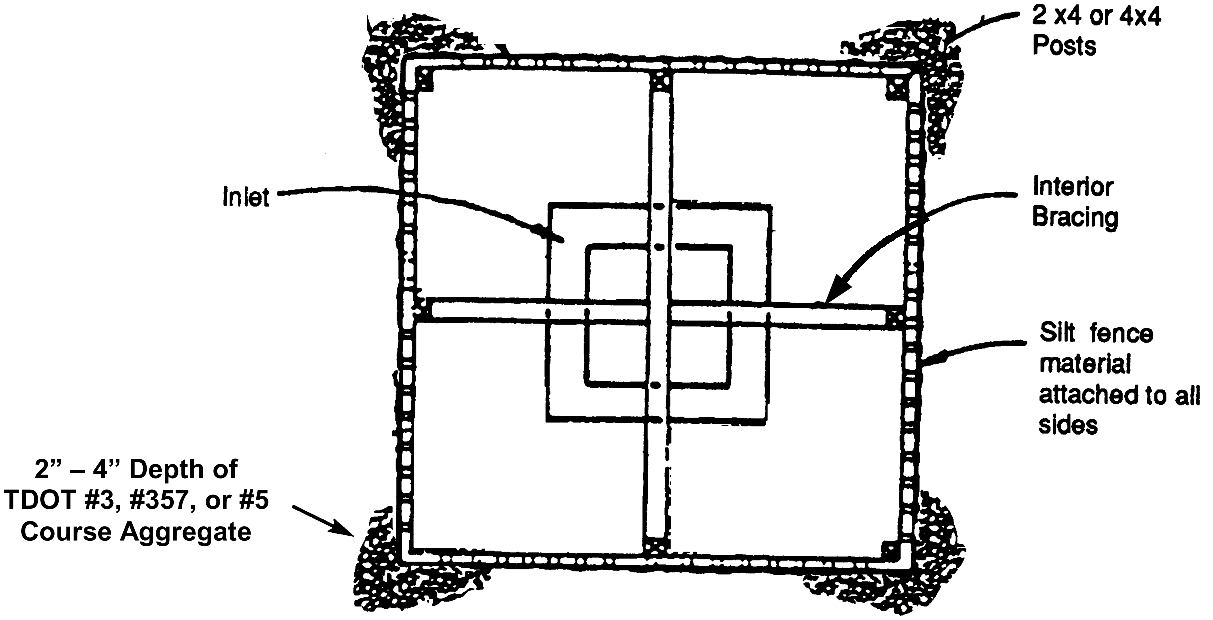


Detail A

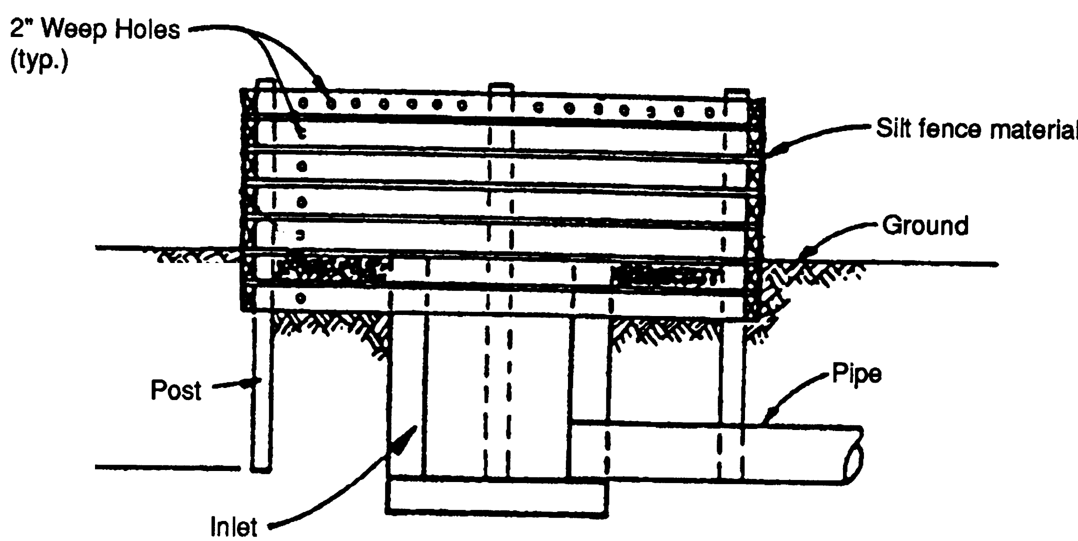
Figure 1

Source: NC SCC

Baffle Box Inlet Protection – IP-BB



PLAN

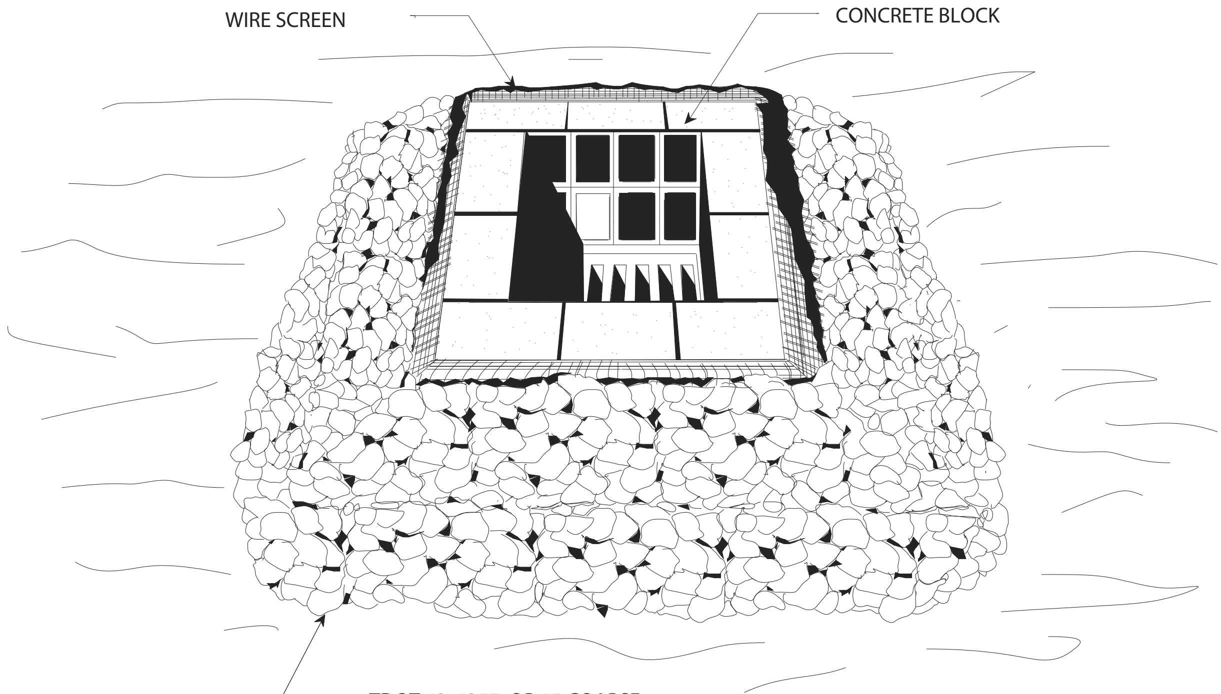


SIDE

Figure 2

Source: GA SWCC

Block and Gravel Inlet Protection - IP-BG



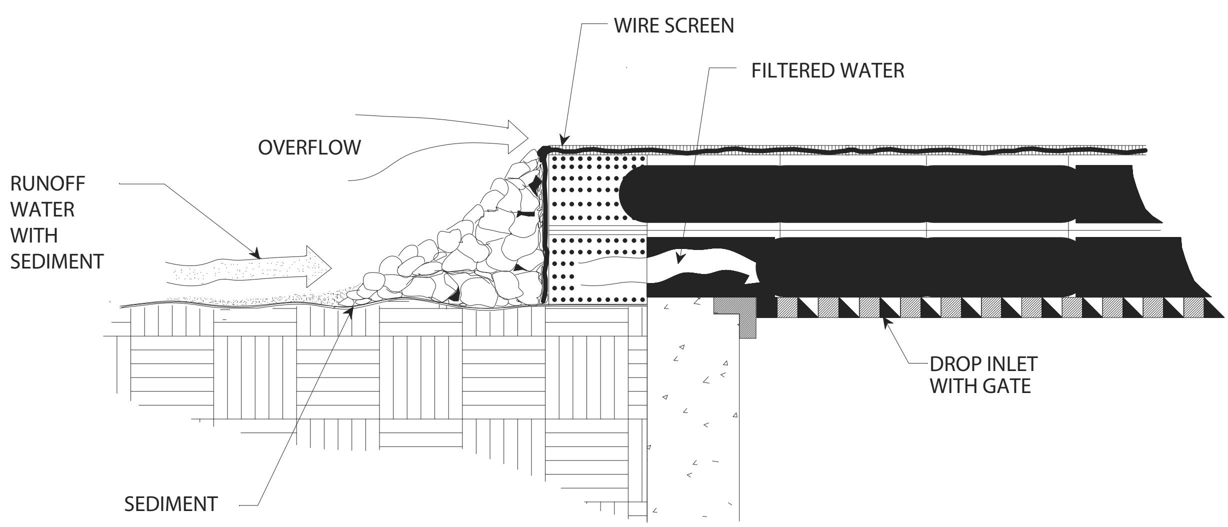
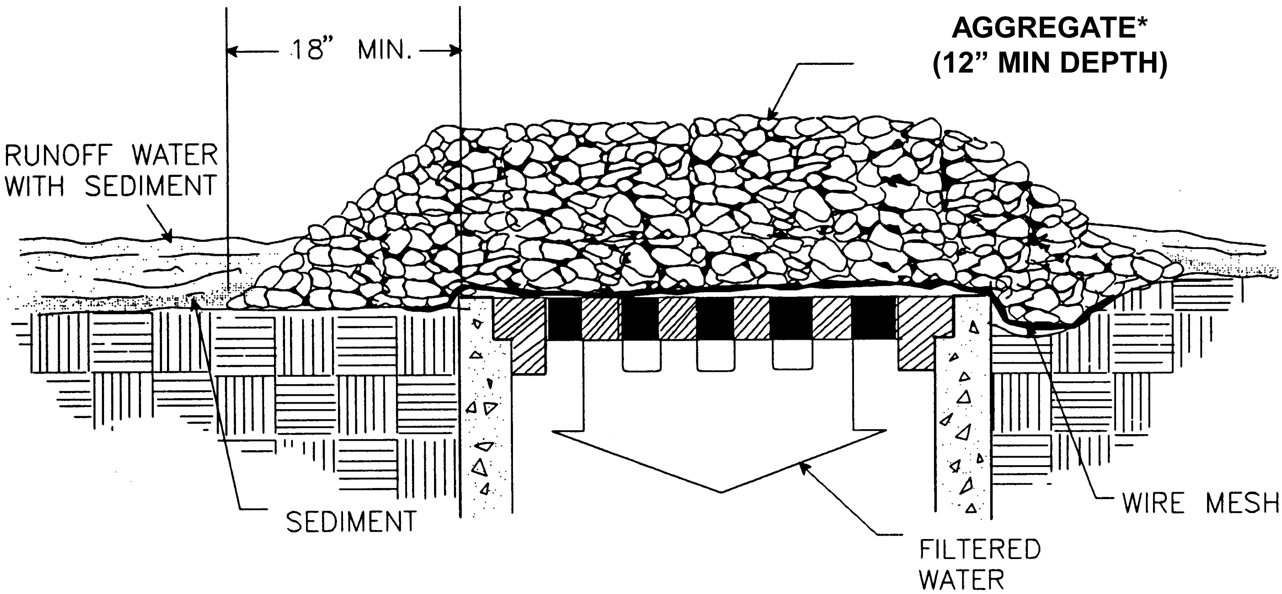


Figure 3

Source: VA DSWC

Gravel Inlet Protection – IP-G

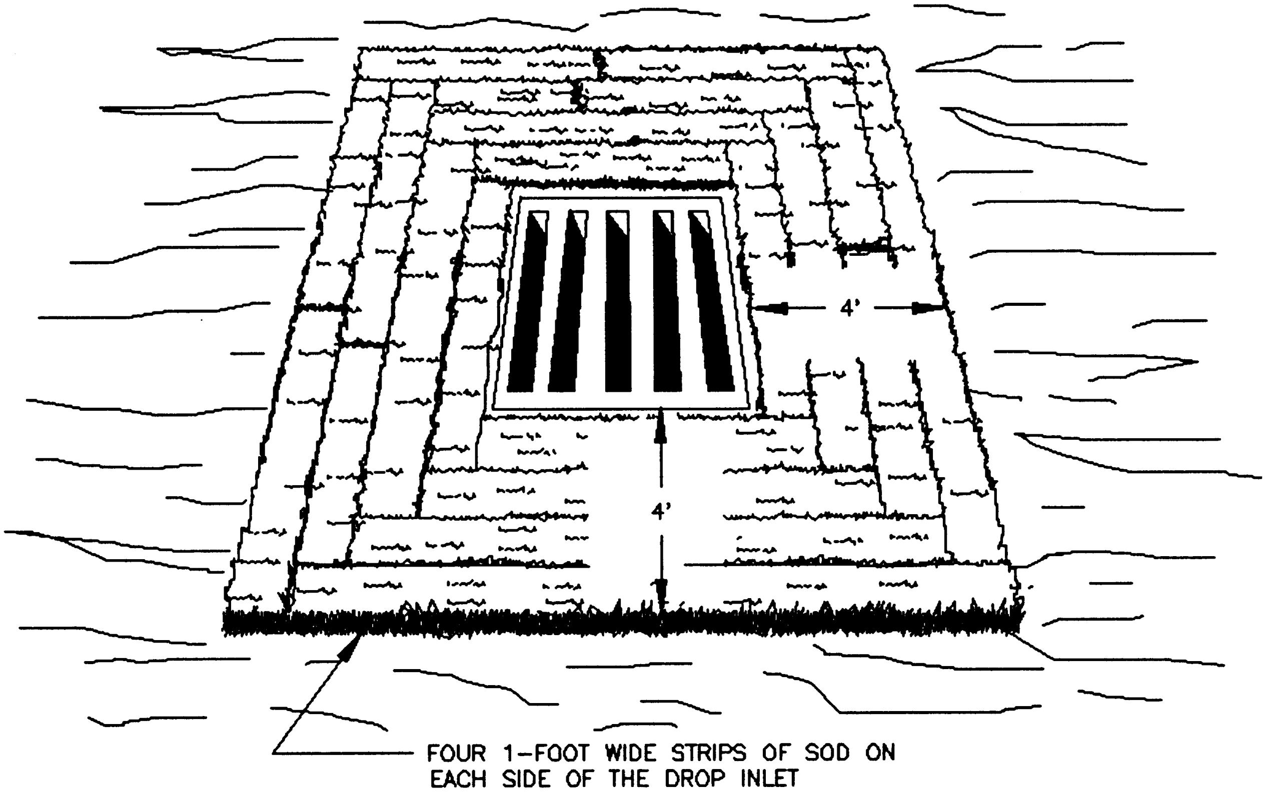


*** COARSE AGGREGATE SHOULD BE TDOT #3, #357, OR #5.**

Figure 4

Source: VA DSWC

Sod Inlet Protection – $\boxed{\text{IP-S}}$



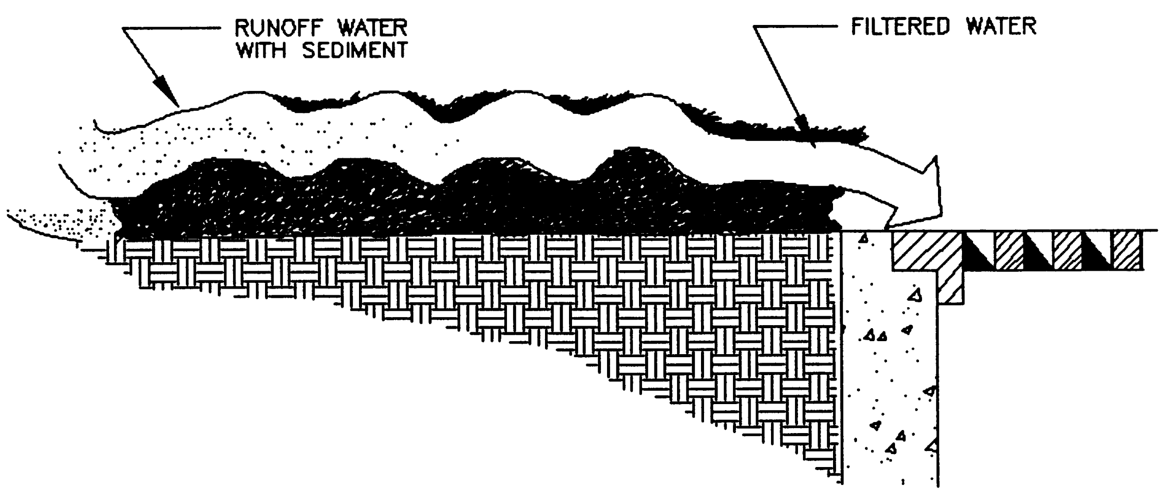


Figure 5

Source: VA DSWC

Storm Drain Outlet Protection - $\boxed{\text{OP}}$

DEFINITION

Paved and/or riprapped channel treatment, placed below storm drain outlets.

PURPOSE

To reduce storm water velocity and dissipate the energy of flow leaving a storm drain before it empties into receiving channels, and to armor erodible materials.

CONDITIONS

This standard applies to all storm drain outlets, road culverts, paved channel outlets, etc., discharging into natural or constructed channels. Treatment will extend between the points where flow exits the storm drain and where flow velocity and/or flow energy from the design storm event is dissipated to the degree where there is minimal to no risk of erosion of the receiving channel.

DESIGN CRITERIA

Structurally lined aprons at the outlets of pipes and paved channel sections should be designed by professionals familiar with storm water conveyance systems and according to the following criteria:

Capacity: The structure should be designed to handle the peak storm flow (Q), in cubic feet per second (cfs), from the 25-year, 24-hour frequency storm, or the design discharge of the water conveyance structure, whichever is greater.

Tailwater Depth: The design depth of thetailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it should be classified as a low tailwater condition. If the tailwater depth is greater than half the pipe diameter, it should be classified as a high tailwater condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a low tailwater condition.

Materials: The apron may be lined with riprap, grouted riprap, or concrete. The median sized stone for riprap (d_{5o}) should be determined according to tailwater conditions described in Table 1. Maximum stone size is equal to 1.5 times the d_{50} value. The gradation, quality and placement of riprap should conform to the specifications in **Riprap – RR.**

Apron Length (L_A): The apron length should be determined according to tailwater conditions described in Table 1.

Apron Width (W_A): See Figure 1. If the pipe discharges directly into a well-defined channel, the apron should extend across the channel bottom and up the channel banks to an elevation one foot above the high tailwater depth or to the top of the bank (whichever is less). If the pipe discharges onto a flat area with no defined channel, the width of the apron should be determined as follows:

1. The upstream end of the apron, adjacent to the pipe, should have a width three times the diameter of the outlet pipe.
2. For a low tailwater conditions, the downstream end of the apron should have a width equal to the pipe diameter plus the length of the apron.
3. For a high tailwater conditions, the down stream end should have a width equal to the pipe diameter plus 0.4 times the length of the apron.

Bottom Grade: The apron should be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron should be equal to the elevation of the invert of the receiving channel. There should be no turbulence at the end of the apron.

Side Slope: If the pipe discharges into a well-defined channel, the side slopes of the channel should not be steeper than 2:1.

Alignment: The apron should be located so that there are no bends in the horizontal alignment.

Geotextile: Geotextiles should be used as a separator between the graded stone, the soil base, and the abutments. The geotextile will prevent the migration of soil particles from the subgrade into the graded stone. The geotextile should be placed in direct contact with the subgrade without any voids. Refer to specification **Geotextile – GE.**

Energy Dissipaters and Stilling Basins: Structural controls, generally made from precast concrete or from pour-in-place concrete, should be used whenever concrete aprons are installed. The design of the energy dissipaters and stilling basins shown in Figure 2 are discussed in the Federal Highways Administration (FHWA) publication HEC- 14, Hydraulic Design of Energy Dissipaters for Culverts and Channels.

Stilling basins are used to convert flows from supercritical to subcritical flow rates by allowing a hydraulic jump to occur. The stilling basin allows a controlled hydraulic jump to occur within the structure over a wide range of flow conditions and depths. A professional engineer using hydraulic computations must design energy dissipaters and stilling basins. A primary concern for both energy dissipaters and stilling basins is whether sediment and trash can accumulate. TDOT drawing standards include a riprap basin energy dissipater, based upon procedures in HEC- 14. The United States Bureau of Reclamation (USBR) also has developed many designs of such structures.

CONSTRUCTION SPECIFICATIONS

1. Ensure that the subgrade for the geotextile and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on undisturbed soil may also be filled by increasing the riprap thickness.
2. Geotextile - Install a geotextile liner to prevent soil movement through the

openings in the riprap. Refer to specification **Geotextile – GE**.

3. Geotextile must meet design requirements and be properly protected from punching or tearing during installation. Repair any damage by removing the riprap and placing another piece of geotextile over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive, replace the entire geotextile liner.
4. Riprap may be placed by equipment, but take care to avoid damaging the geotextile.
5. The minimum thickness of the riprap should be 1.5 times the maximum stone diameter, but not less than 6”.
6. The outlet structure must conform to the specified grading limits shown on the plans.
7. Construct the apron on zero grade with no turbulence at the end. Make the top of the riprap at the downstream end level with the receiving area or slightly below it.
8. Ensure that the apron is properly aligned with the receiving stream and, preferably, straight throughout its length.
9. Immediately after construction, stabilize all disturbed areas with vegetation.
10. Stone quality - Select stone for riprap from fieldstone or quarry stone. The stone should be hard, angular, and highly weather-resistant. The specific gravity of the individual stones should be at least 2.5. Refer to specification **Riprap – RR**.

MAINTENANCE

Inspect riprap outlet structures after heavy rains to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Immediately make all needed repairs to prevent further damage.

Riprap Outlet Protection Specifications

This table is intended to select two parameters for the design of riprap outlet protection, based upon outlet velocities that correspond with circular culverts flowing full. Flow values less than the lowest value for the culvert size usually indicate a full-flow velocity less than 5 feet per second, for which riprap is usually not necessary. Flow values more than the highest value for the culvert size usually indicates that a concrete stilling basin or energy dissipater structure is necessary.

Adjust values upward if the circular culvert is not flowing full based upon outlet conditions. For noncircular pipe, convert into an equivalent cross-sectional area of circular culvert to continue design.

Riprap Aprons for Low Tailwater (downstream flow depth < 0.5 x pipe diameter)

Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	7	2.5	6	10	3.5	9	131	6	12	16	7	14	17	8.5
15"	6.5	8	3	10	12	5	15	16	7	20	18	10	25	20	12
18"	10	9	3.5	15	14	5.5	20	17	7	30	22	11	40	25	14
21"	15	11	4	25	18	7	35	22	10	45	26	13	60	29	18
24"	21	13	5	35	20	8.5	50	26	12	65	30	16	80	33	19
27"	27	14	5.5	50	24	9.5	70	29	14	90	34	18	110	37	22
30"	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36"	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42"	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48"	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

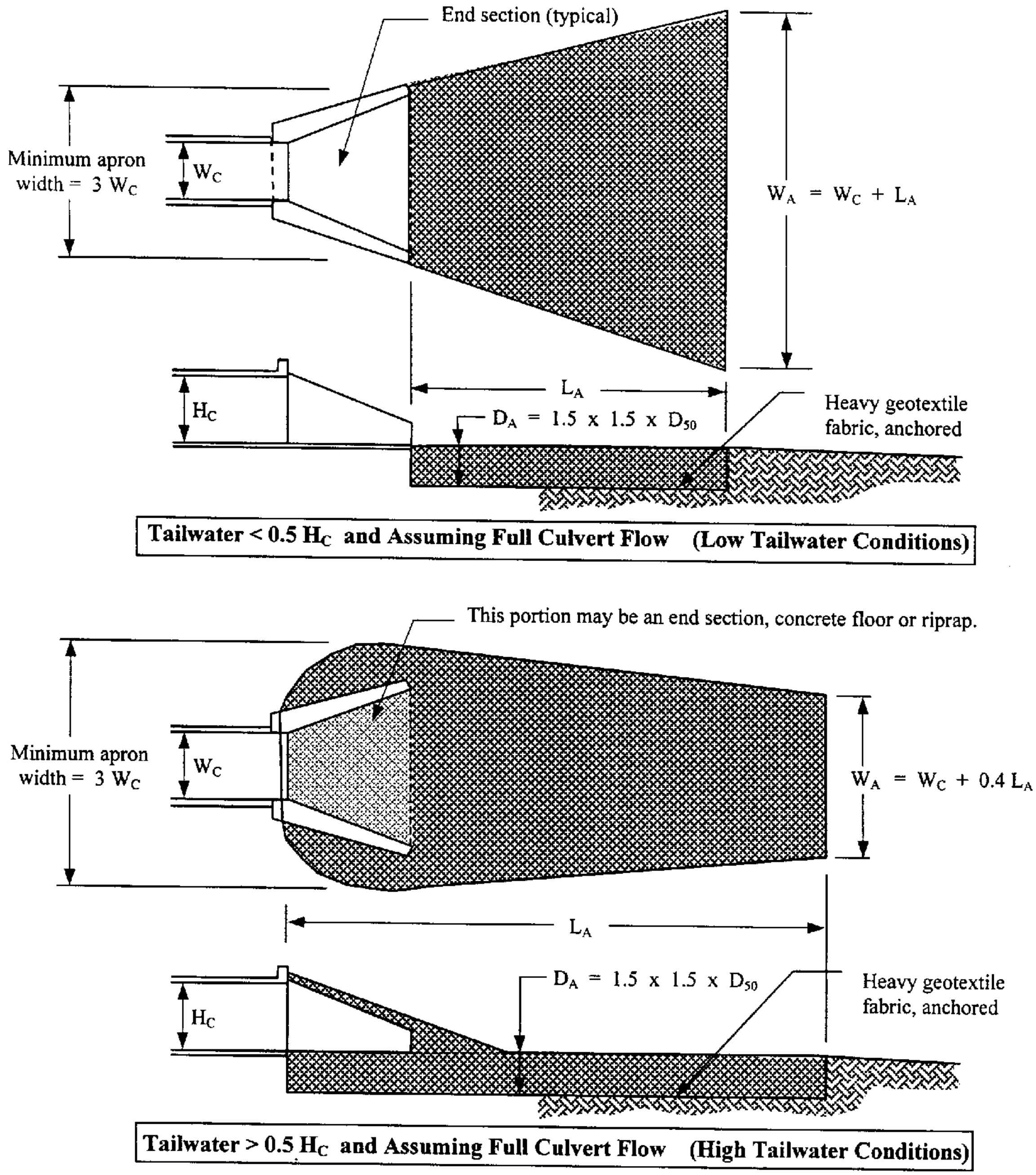
Riprap Aprons for High Tailwater (downstream flow depth > 0.5 x pipe diameter)

Culvert Diameter	Lowest value			Intermediate values to interpolate from									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12"	4	8	2	6	18	2.5	9	28	4.5	12	36	7	14	40	8
15"	7	8	2	10	20	2.5	15	34	5	20	42	7.5	25	50	10
18"	10	8	2	15	22	3	20	34	5	30	50	9	40	60	11
21"	15	8	2	25	32	4.5	35	48	7	45	58	11	60	72	14
24"	20	8	2	35	36	5	50	55	8.5	65	68	12	80	80	15
27"	27	10	2	50	41	6	70	58	10	90	70	14	110	82	17
30"	36	11	2	60	42	6	90	64	11	120	80	15	140	90	18
36"	56	13	2.5	100	60	7	140	85	13	180	104	18	220	120	23
42"	82	15	2.5	120	50	6	160	75	10	200	96	14	260	120	19
48"	120	20	2.5	170	58	7	220	85	12	270	105	16	320	120	20

Table 1

Source: Knoxville Engineering Department

Riprap Outlet Protection



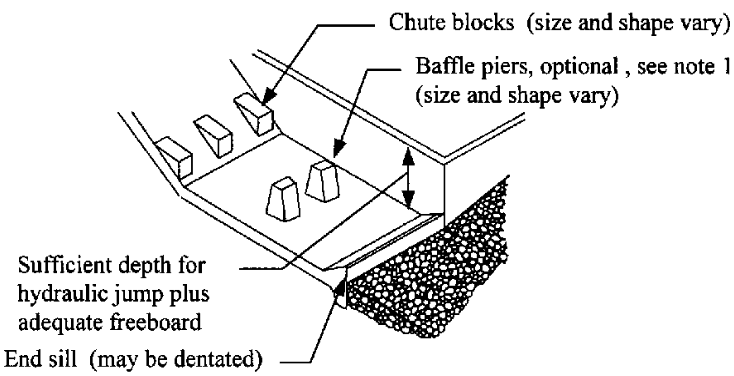
NOT TO SCALE

H_C = height of culvert
W_C = width of culvert
L_A = length of riprap apron
W_A = width of riprap apron at end
D_{50} = median riprap size
D_{MAX} = maximum size of riprap = 1.5 D_{50}
D_A = depth of riprap apron = 1.5 D_{MAX}

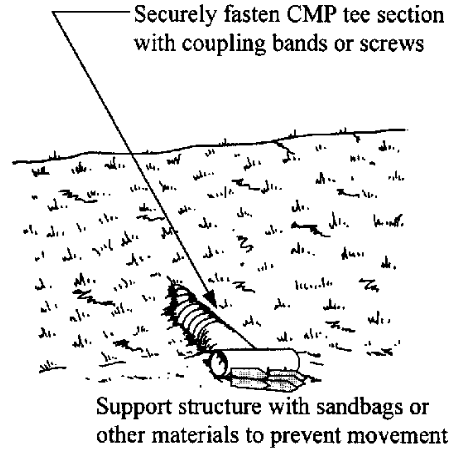
Figure 1

Source: Knoxville Engineering Department

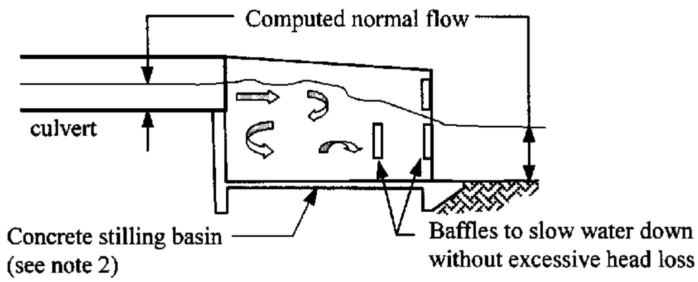
Various Energy Dissipaters and Stilling Basins



Typical Stilling Basin At End of Paved Flume or Chute



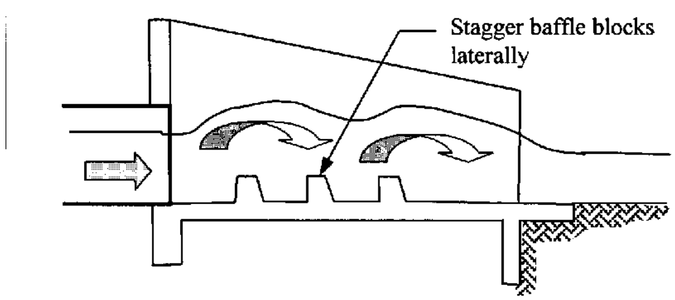
Temporary CMP Energy Dissipator



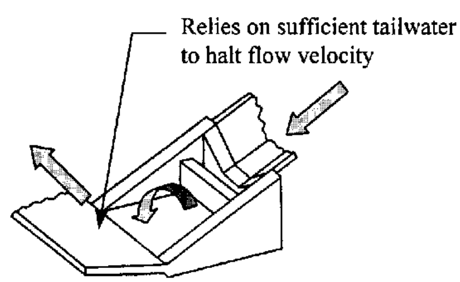
Typical Stilling Basin Using Baffles and Elevation Drop

Notes:

1. This is the basic format for several types of stilling basins. USBR Type II basin does not contain baffle piers, but does have a dentated end sill. USBR Type III basin has baffle piers and a smooth undentated end sill. See HEC-14 for detailed design of concrete structures.
2. Concrete stilling basin should be approximately as wide as the downstream channel. Design baffles to retain sufficient stormwater to act as a plunge pool for a wide range of flow values.



Typical Energy Dissipator – Baffle Blocks Within Headwall



Typical Impact Energy Dissipater (Virginia DOT)

Figure 2

Source: Knoxville Engineering Department

Surface Roughening - SR

DEFINITION

The use of mechanized equipment to apply a rough texture to soils at final grade.

PURPOSE

Surface roughening or scarification is a technique used for creating unevenness on bare soil to prevent slope erosion and the formation of rills. The primary functions of surface roughening are to:

- Reduce erosion potential by decreasing runoff velocities
- Trap sediment
- Increase infiltration of water into the soil
- Aid in the establishment of vegetative cover

DESIGN CRITERIA

Roughening methods with agricultural equipment include tilling, disking or harrowing, which must be done across the slope along the contour. Tracking (Figure 1) with tracked equipment, by contrast, must be done up and down the slope. Factors to be considered in choosing a method include slope steepness, long term slope maintenance and mowing requirements, type of soil, and whether the slope is formed by cutting or filling. Generally, a slope cannot be mowed if it is steeper than 3:1 (H:V). Roughening is performed after the slopes have been graded and dressed. Steep slopes may require the techniques discussed in specification **Gradient Treatment - GT.**

Cut Slope Roughening: Cut slopes are created by the removal of soil and/or rock material leaving a newly exposed slope face. Tilling, disking, and harrowing are acceptable methods of roughening a cut slope. Groove the slope using machinery to create a series of ridges and depressions that run across the slope and on the contour. Make grooves less than 10 inches apart and not less than 1 inch deep. Excessive roughness is undesirable where mowing is planned.

Roughening with tracked machinery should preferably be limited to soils with a sandy textural component to avoid undue compaction of the soil surface. Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Each pass should move across the slope gradually. Apply fertilizer, mulch, topsoil, or other soil amendments as necessary prior to grooving or tracking. Do not blade or scrape the final slope face.

Fill Slope Roughening: Fill slopes are created by the placement of fill material in a position that creates a slope. Fill slopes are not as stable as cut slopes, no matter how much compaction is applied. The face of the slope should consist of loose uncompacted fill 4 to 6 inches deep.

Use grooving or tracking to roughen the face of the slopes as necessary. Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Each pass should move across the slope gradually. Apply fertilizer, mulch, topsoil, or other soil amendments as necessary prior to grooving or tracking. Do not blade or scrape the final slope face.

Stabilization: Once the treatment has been applied take the appropriate measures to stabilize all the bare area. Refer to specifications **Disturbed Area Stabilization (With Permanent Vegetation) - PS,** and **Matting and Blankets - MA.**

MAINTENANCE

Maintenance needs identified in inspections or by other means should be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

Surface Roughening

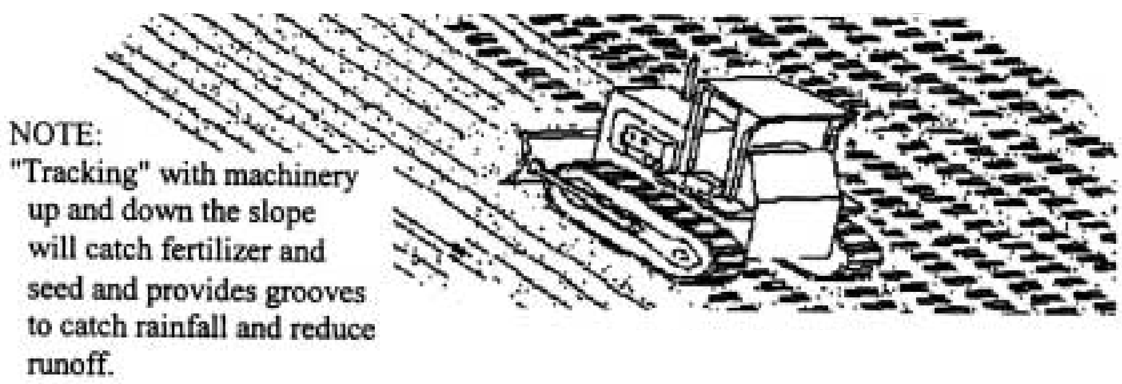


Figure 1

Source: Knoxville Engineering Department